ADVANCED TEXT-BOOK

OF

PHYSICAL GEOGRAPHY

" In considering the study of physical phenomena, not merely in its bearings on the material wants of life, but in its general influence on the intellectual advancement of mankind, we find its noblest and most important result to be a knowledge of the chain of connection by which all natural forces are linked together and made mutually dependent upon each other; and it is the perception of these relations that exalts our views and ennobles our enjoyments."—HUMBOLDT'S *Cosmos*.

PREFACE.

In connection with his Text-Books of Geology, the Author has long meditated the production of two similar works on the closely-allied science of Physical Geography. The two subjects are most intimately connected—Geology forming, as it were, the groundwork of Geography, and Geography, on the other hand, becoming the field in which the operating causes of Geology are most obviously and intelligibly at work. The one becomes, in fact, the complement of the other; and the student of Geology can have no better preliminary training than a systematic course of Physical Geography; while the student of Geography cannot more readily ascend to the higher problems of his science than through the teachings of Geology. Though thus closely related, the two sciences may be studied, each on its own basis; and a large amount of knowledge may be acquired respecting the geographical conditions of the world —its lands, waters, and atmosphere; their mutual actions and reactions; the distribution of mineral, vegetable, and animal productions; and the bearings of these on the intellectual and social progress of man—without knowing more of Geology than merely being able to appreciate and apply its more obvious deductions.

Convinced of this, the Author has endeavoured to produce an Introductory and an Advanced Text-Book of Physical Geography, in accordance with the requirements of modern education, and the advancing state of the natural sciences. As the Introductory is not a mere narration of dry facts, to be irksomely committed to memory, but an outline of phenomena and principles to be read and reasoned; so the Advanced, avoiding the argumentative character of a scientific essay, aims at something more than a bulky compilation of disjointed descriptions, and not unfrequently contradictory statements. In both instances a systematic treatment has been strictly adhered to; and while the Introductory may meet the requirements of junior students, and those who cannot command time for an extended course, the Advanced, it is hoped, will satisfy the wants of senior students, as well as of those who merely seek a general acquaintance with the natural phenomena of our planet. The explanation of principles, rather than a detail of facts, has been a main object throughout, that the student may be enabled to apply them to his own observations and readings—readings that become every year more extensive, from the increasing facilities for travel in remote and imperfectly known regions.

To assist the student in the comprehension of his subject, an extensive Glossary of Terms has been appended, and a number of illustrations inserted in the text; but the accompaniment of maps has been rendered unnecessary by the recent publication of several excellent Atlases of Physical Phenomena, and, above all, by those constructed by Mr Keith Johnston, and issued at very moderate prices by the publishers of the present treatise.

GILMORE PLACE, EDINBURGH,
June 1864.

CONTENTS.

		PAGE
I.	INTRODUCTORY OUTLINE,	11-17
	Aim and Objects of the Science,	11
	Theoretical and Practical Bearings,	14
II.	THE EARTH—ITS GENERAL OR PLANETARY RELATIONS,	18-32
	Figure, Motions, Dimensions,	18
	Density, Temperature, Atmosphere,	23
	Technical Subdivisions—Points, Circles, Zones, &c.,	27
III.	THE EARTH—ITS INDIVIDUAL STRUCTURE AND COMPOSITION,	33-45
	The Rocky Crust—Its Constitution and Formation,	33
	Relative Age and Arrangement of Rock-Formations,	36
	Connection between Geology and Physical Geography,	43
IV.	DISTRIBUTION OF LAND AND WATER,	46-57
	Their Relative Positions and Areas,	46
	Their Subdivisions, Natural and Technical,	51
	Their Mutual Actions and Reactions,	55
V.	THE LAND—ITS CONFIGURATION,	58-69
	Relative Position,	58
	Contour or Horizontal Outline,	59
	Vertical Relief or Elevation,	62
	Causes and Consequences of Configuration,	67

		PAGE
VI.	THE LAND—ITS HIGHLANDS,	70-99
	Mountains and Mountain-Systems,	70
	European Systems,	74
	Asiatic Systems,	78
	African Systems,	83
	Australasian and Polynesian Systems,	85
	American Systems,	85
	Table-lands or Plateaux,	92
VII.	THE LAND—ITS LOWLANDS,	100-112
	Plains and Deserts,	100
	Valleys and Minor Depressions,	107
	Origin and Characteristics of Lowlands,	109
VIII.	THE WATER—ITS OCEANS AND SEAS,	113-128
	Their Area and Configuration,	113
	Composition, Density, Pressure, Depth, &c.,	118
	Temperature, Colour, Luminosity, &c.,	124
IX.	THE WATER—ITS OCEANS AND OCEAN-CURRENTS,	129-147
	Waves—their Height, Velocity, and Impact,	129
	Tides—their Origin and Influence,	131
	Currents—their Causes and Functions,	13'
X.	THE WATER—ITS RIVERS AND LAKES,	148-184
	Springs and Streams,	150
	Rivers—their Characteristics,	154
	River-Systems, Oceanic and Continental,	.59
	Lakes and Lacustrine Areas,	177
XI.	THE ATMOSPHERE—CLIMATOLOGY,	18-204
	Nature and Constitution of the Atmosphere,	185
	Its Heat and Moisture,	188
	Winds—Constant, Periodical, and Variable,	193
XII.	THE ATMOSPHERE—CLIMATOLOGY,	205-223
	Dew, Rain, Hail, Snow, &c.,	205
	Causes affecting Climate,	215
	Lines of Equal Heat, &c.,	218

PAGE

XIII. LIFE—ITS DISTRIBUTION AND FUNCTION, . . 224-237
Life as affected by External Conditions, . . 224
Plant-Life—Its Distribution and Governing Conditions, 227

XIV. LIFE—ITS DISTRIBUTION AND FUNCTION, . . 238-246
Animal Life—Its Distribution and Governing Conditions, 238
Interdependence of Plants and Animals, . . 243

XV. ETHNOLOGY—VARIETIES AND RACES OF MAN, . 247-260
Man as affected by External Conditions, . . 247
Characteristics and Distribution of Race, . . 249
Conditions of Civilisation and Progress, . . 257

XVI. GENERAL REVIEW, APPLICATIONS, AND DEDUCTIONS, 261-296
Objects and Principles, ... 261
Continental Aspects, ... 267
Europe, ... 267
Asia, ... 272
Africa, ... 277
North America, ... 281
South America, ... 286
Oceania, ... 291
Conclusion, ... 295

GLOSSARY OF TERMS, ... 297-316

INDEX, ... 317-320

PHYSICAL GEOGRAPHY.

I.

INTRODUCTORY OUTLINE.

Aim and Objects of the Science.

1. GEOGRAPHY (from two Greek words, *ge*, the earth, and *graphe*, a writing or description) embraces, in its widest sense, all that can be known of the superficial aspects of our globe—its lands and waters, their extent and configuration, their altitude and depth, the atmosphere that surrounds them, their varied conditions and climate, and, finally, the distribution of the plants and animals by which they are respectively peopled. As Geology labours to interpret the rocky structure of the earth, and to write the history of the various mutations that structure may have undergone; so Geography endeavours to describe its external conditions, and to explain the causes by which these conditions are produced, and the purposes for which they are apparently maintained.

2. A science embracing so wide and varied a subject will readily present itself under several heads or departments; and thus we may have what is termed *Mathematical Geography*, which devotes itself to the size, form, motions, and general divisions of the earth as a planet, forming part of the solar system; *Political Geography*, which relates to the arbitrary subdivisions of the earth into empires kingdoms, and states, with their populations, manners, religion, laws, industry, commerce, and other features distinctive of such subdivisions; *Descriptive* or *General Geography*, which restricts itself to a mere account of the external aspects of the lands and

waters—their extent and configuration, their scenery, life, and other obvious features—without inquiring into the causes that produce these appearances; and lastly, we may have *Physical Geography*, which, while it embraces all the natural conditions of the lands and waters depicted by Descriptive Geography, proceeds further to inquire into the causes that produce these results, and by which they are in the course of nature continually reproduced within certain limits of change and modification.

3. Physical Geography is thus the higher department, its aim being not only to describe the external aspects or the terraqueous (land and water) globe, but to inquire into those conditions of position, altitude, soil, heat, moisture, and the like, which govern the distribution of plants and animals on the land, and those conditions of depth, composition, and temperature, which regulate in a similar manner the distribution of plants and animals in the ocean. The Land, its continents and islands, its mountains and valleys, its soil and climate, its scenery and life-arrangements; the Ocean, its seas and bays, its shoals and depths, its composition and temperature, its aspects and life-dispersion,—are the special objects of Physical Geography; and its highest aim the discovery and expression of those laws which regulate the action and reaction of land, water, and atmosphere in the production of physical phenomena. Physical Geography thus rises above the mere description of external appearances, and seeks to explain the causes that produce them—arranging the whole into a system of world-machinery whose modes of action can be understood, and whose results it is possible to determine. In the eloquent language of the author of 'Earth and Man' (M. Guyot)—"Geography ought to be something different from a mere description. It should not only describe, it should compare, it should interpret, it should rise to the *how* and the *wherefore* of the phenomena which it describes. It is not enough for it coldly to *anatomise* the globe, by merely taking cognisance of the arrangement of the various parts which constitute it. It must endeavour to seize those incessant mutual actions of the different portions of physical nature upon each other, of inorganic upon organised beings, upon man in particular, and upon the successive developments of human societies; in a word, studying the reciprocal action of all these forces, the perpetual play of which constitutes what may be called the Life of the Globe, it should, if I may venture to say so, take up its *Physiology*. To understand it in any other way, is to deprive Geography of its vital principle; it is to make it a collection of partial, unmeaning facts; it is to fasten upon it for ever that character of dryness, with which it has so often and so justly been reproached. For what is dryness in a science,

except the absence of those principles, of those ideas, of those general results, by which well-constituted minds are nurtured?"

4. Rising to this conception of his science, and viewing the beautiful and diversified field before him, the student of Geography meets a problem in every phenomenon that presents itself, and finds a solution in every incident that occurs. Why, for instance, do two countries, lying within the same parallels of latitude, present such differences in climate? Why are mountain-heights perpetually enveloped in snow, while the lower ridges are clothed in verdure and blossom? Why does one region of a continent be arid and rainless, while another is deluged with periodical torrents? Why do the winds in certain latitudes blow steadily and for weeks in one direction, while in another they are fitful and irregular? Why should one expanse of ocean be still and tideless, while another swells and falls with tides, and is traversed by currents? Why should the plants and animals that flourish in one region, dwarf and die out if transferred to another that seems equally fertile in soil and genial in climate? Why should the men at the mountain foot be tillers of fields and dressers of vineyards, while those a thousand feet higher are herdsmen and shepherds? Or why should one country be the scene of busy industry and successful commerce, of intellectual activity and mental culture, while another, as fair and even more fertile, remains the mere squatting-grounds of indolent, dependent, and semi-civilised hordes? These and a thousand similar questions press themselves upon the attention of every geographical observer; and while the facts may be detailed with clearness and accuracy by Descriptive Geography, to Physical Geography, in particular, we must turn for a rational solution of the phenomena presented.

5. In the prosecution of his subject the student of Physical Geography appeals to Astronomy for what relates to the figure, size, motions, and other primary conditions of our planet; to Geology for the structure and constitution of the rocky crust, which forms, as it were, the groundwork of all Geography; to Meteorology for much that belongs to climate and its allied phenomena; while from Chemistry and Physiology he derives important aid in dealing with the nature, growth, and dispersion of plants and animals. There, for example, is an island in the ocean: what is its position on the earth's surface—that is, its latitude and longitude; when will its sun rise and set, compared with some fixed meridian; what are the limits of its seasons; when will its tides ebb and flow; what is the force of gravity at its surface; what the deviation of the magnetic needle? and many other similar questions. These, strictly speaking, belong to Astro-

nomy and Mathematics; but the geographer, availing himself of their aid, appeals to them for the solution of these problems. Again, the island is rocky and precipitous towards the north and west, while towards the south and east it falls away in gentle slopes and terraces. The north-western section presents, in the main, a series of basaltic crags and rocky hill-tops, while the south-eastern consists of clays and loams that lie on upturned strata of sandstones, limestones, and shales. There is a small circular lake or tarn up among the hills, while along the junction of the sandstones and basalt numerous springs rise and find their way to the low lands below. This is the structure of the island, and Geology endeavours to explain it. Further, while the hill-tops are often enveloped in mists, the lower slopes rejoice in sunshine; and not unfrequently, when the heights are covered with snow, the low grounds are fresh and open. The rainfall on the western coast is several inches more than that on the east; and the north-east winds are cold and parching, while the south-west are warm and laden with moisture. This is its Climatology, and Meteorology lends her aid to an explanation of these opposing phenomena. Still further, the plants that flourish on the basaltic crags are never found on the clayey slopes below; while even on the slopes and terraces different plants affect different soils, though exposed to the same sunshine and moisture. Chemistry and Physiology resolve these problems; and Physical Geography, while it describes and accounts for the whole, must own her obligations to these and other allied departments of natural science. Though drawing, however, in this manner from other sciences, it by no means follows that the student should be deeply read in Astronomy, Geology, or Meteorology. All that is necessary is that he be able to perceive the connection and interbearings of these sciences, and be capable of appreciating the importance of their deductions in as far as they relate to his own immediate study of Physical Geography.

Theoretical and Practical Bearings.

6. The value of such a science must be obvious to the most casual observer. To determine the relative extent of the land and water that constitute this terraqueous surface—the varying altitudes of the one and the depths of the other, the climates of the one and the winds and currents that traverse the other, with the infinitely diversified mineral, vegetable, and animal productions of both—is not only a source of high intellectual enjoyment

and culture, but a task of prime industrial necessity. This globe is the sole scene of man's earthly labours—his cradle, the theatre of his life-actions, his grave! Scattered over its surface, separated by sea and mountain, enjoying different climates, and placed in proximity to different mineral, vegetable, and animal products, it is a natural necessity that different nations should trade and barter with each other. To ascertain the peculiarities of this varied surface, to learn the variety of its products—to know all, in fine, that relates to the home we tenant, and the comforts and necessaries with which it is furnished, as well as the obstacles or facilities that lie in the way of obtaining them—is the sum and substance of Geography. The observation and reasoning required in geographical research, the amount of information obtained, and the curiosity gratified by faithful descriptions of distant and diverse regions, constitute, on the one hand, its theoretical value; acquaintance with their mineral, vegetable, and animal products, now so indispensable to civilised existence, the conditions under which these occur, and the capability of the latter for naturalisation in other countries, form, on the other hand, its economical or practical importance.

7. To the navigator dependent on the winds and currents of the ocean, what more necessary than a knowledge of the times, directions, and limits of these aërial and aqueous movements? The determination of shoals and sandbanks, of sunken rocks and reefs, is no doubt highly valuable; but it is a higher effort of philosophy to determine the causes and courses of these wind and water currents—to teach the sailor how to shun the storms of the one, and to cast himself on the favouring stream of the other. To the pioneer and settler in new lands, what more important than a knowledge of the climate, the seasons, and the products of his adopted home? or what more valuable than the teachings of Physical Geography to the merchant-traveller in search of new objects of enterprise and sources of wealth? To the botanist and zoologist, who deal with the strictly scientific aspects of natural history, as well as to the gardener and farmer, who seek to naturalise the plants and animals of different regions, there is no science whose bearings are so immediate as that which reveals the geographical distribution of life, and the causes that determine the order of that distribution. To the physiologist and psychologist who would study the influence of climate and other external conditions on health as well as on mental character; and to the political economist and statesman who have to deal with the peculiarities of different nations and the products of their countries, Physical Geography becomes a science of direct and important

interest. Combining, therefore, its theoretical with its practical bearings, our science has paramount claims alike on the attention of the philosopher, the statesman, the sailor, the farmer, the merchant, and manufacturer.

8. To present an outline of this science in its higher bearings is the object of the present treatise; and the student will best accomplish his purpose who step by step confirms the statements of the text by reference to the maps of his Atlas. By this double process any little difficulty will be more readily mastered, while the facts will be fixed more clearly and permanently on the memory. Every principle, thoroughly understood, becomes a key to some other problem; hence the value of systematic treatment, and the necessity of a clear comprehension of the successive stages by which the higher problems are attained. The study of General Geography—the positions of towns, courses of rivers, heights of mountains, and the like—is for the most part little better than a task of memory; Physical Geography, on the other hand, requires reasoning at every step, and the student will find his reasonings greatly assisted not only by the systematic use of his Atlas, but by the habit of appealing to the phenomena presented by his own immediate district. There are few localities, however limited, that do not present their alternations of hill and dale, of lake and river, of warm winds and cold winds, of periods of drought and periods of rainfall, of plants that love the marsh and others that thrive only in the thirsty upland; and by noting such distinctions, and the causes concerned in their production, the mind by such training will be better prepared for the comprehension of the phenomena of wider and more varied regions. As the botanist, zoologist, and geologist find the objects of their studies in every walk through the fields around them, so the student of Physical Geography will find the illustrations of his science in every locality he may visit. Every district has its own features of high-land and low-land, its streams and lakes and rivers, its peculiar winds and rains and frosts, its special arrangements of plants and animals; and he who understands best the governing causes of these local peculiarities will be best able to deal with the general problems of Physical Geography. There is nothing fortuitous in the economy of our planet: every breeze that blows, every cloud that sweeps across the firmament, and every shower that falls—fickle, uncertain, and local as these may appear—are as much the results of law and law-directed forces as the rising and falling of the tides or the revolutions of the planets. Impressed with this conviction, and seeing how closely every incident in nature is connected with another, the student will consider no occurrence as too trivial,

and no fact as too insignificant, to deserve his attention. Impressed with this conviction, the most fitful and uncertain phenomena assume the character of regularity and order, and the determination of the law of their recurrence becomes a hopeful and exhilarating pursuit.

NOTE, RECAPITULATORY AND EXPLANATORY.

In the preceding paragraphs we have endeavoured to show that the object of Physical Geography is to describe the external conditions of the globe, and discover the causes by which they are maintained or modified. It treats of the earth's surface as composed of land and water, determines their extent and configuration, their altitude and depth, the climate and other conditions that influence the growth and distribution of the plants and animals by which they are respectively peopled, and, rising above these, endeavours to account for the mental and social peculiarities of different nations as seemingly dependent on external phenomena. Deriving from Astronomy what relates to the figure, dimensions, motions, and other primary features of our planet; from Geology the structure and composition of its rocky crust; from Meteorology the proximate causes of the diversity of climates; and from Chemistry and Physiology the more intimate nature of vegetable and animal life,—Physical Geography proceeds to apply these adjuncts to its own proper field of inquiry, and from the whole deduces a rational and connected account of the cosmical phenomena by which we are surrounded. "Its ultimate aim," in the words of the immortal Humboldt, "is to recognise unity in the vast diversity of phenomena, and by the exercise of thought and the combination of observations, to discern the constancy of phenomena in the midst of apparent changes." As a science of observation and deduction in connection with the external conditions of the beautiful planet we inhabit, it possesses high intellectual attractions; and as bearing on its mineral, vegetable, and animal products—their abundance, distribution, and capabilities of dispersion —it becomes to civilised nations a study of prime industrial importance.

II.

THE EARTH—ITS GENERAL OR PLANETARY RELATIONS.

Figure, Motions, Dimensions.

9. By the general relations of the earth are meant those primary conditions of form, size, density, motion, and the like, which belong to it as a member of the planetary system. From these conditions arise all those multifarious actions and reactions that take place on its surface—the alternations of night and day, heat and cold, summer and winter, growth and decay, the winds and motions of the atmosphere, the tides and currents of the ocean, and, in fact, all that confers on it geographical diversity and change. Thus, on its axial rotation depends the recurrence of light and darkness; from its revolution round the sun arises the succession of the seasons, with all their varied effects on vegetable and animal life; from the unequal reception of the sun's heat by the terraqueous surface and atmosphere result the multifarious phenomena of what we call weather and climate; while from the attraction of the sun and moon, and the earth's own proper motions, spring the flow and ebb of the tides, and the other great currents of the ocean. The consideration of these conditions belongs, no doubt, more especially to Astronomy and Physics, but as much may be here recapitulated as will enable the student to lay the foundation, as it were, of his own special science.

10. The province of Physical Geography is not merely to observe and describe, but to explain and determine. Here is a globe revolving and rotating in obedience to the laws of gravitation and attraction; and as motion is inseparably associated with change—change of place or change of condition—the nature of these changes, and the secondary results arising therefrom, constitute the legitimate themes of our science. Manifested on or near the accessible surface, these phenomena become apparent to every observer; but the producing causes are often so complicated by action and reaction on each other, that without a knowledge of the general

relations of the earth, it would be impossible to arrive at a satisfactory determination. As there is no independent existence in nature, so it is necessary to have some idea of the whole; and as our planet is but one of a brotherhood, it is necessary to the comprehension of its individual constitution to have some notion of the relations that subsist between the fraternity. It is for this reason that Geography appeals to Astronomy for a knowledge of the planetary conditions of the earth, in as far, at least, as these appear to bear on its superficial phenomena.

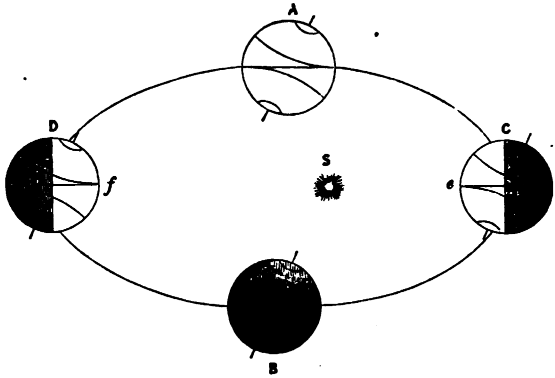
11. Astronomers have determined that the earth we inhabit is one of a number of planets that revolve, at different distances and with different velocities, round the sun as a common centre, constituting what is termed the *Solar System* (Lat. *sol*, the sun). These bodies—some of which are nearer the sun than our earth, and others more remote, some vastly larger, and others smaller—are nearly all spherical in form, and move from west to east, in courses or *orbits* more or less circular. The distance of the earth from its central orb is 95,173,000 miles, or, in round numbers, ninety-five millions of miles. Its time of revolution round the sun is about 365¼ days—or, more precisely, 365 days, 5 hours, 48 minutes, and 50 seconds—and this period of revolution we designate *a year*. Besides this annual revolution round the sun, the earth rotates or turns on its own axis in 24 hours, or, more exactly, in 23 hours, 56 minutes, and 4 seconds—and this period of rotation constitutes *a day*. In other words, the earth rotates three hundred and sixty-five times during the course of a single revolution; and thus the more frequent and obvious motion of daily rotation has been taken as the unit of measurement for the larger and less apparent. In these movements of annual revolution and daily rotation, the earth, like several other of the primary planets, is attended by a minor or secondary body, which revolves round her as she round the great central luminary of the system. This secondary planet or *satellite* (Lat. *satelles*, an attendant) is the Moon, which is 2160 miles in diameter, and which completes her revolution round her parent orb (at a distance of 24,000 miles) in 27 days, 8 hours—or, in round numbers, in 28 days, or one lunar *month*. These motions and times of motion are determined and influenced by the attraction and gravitation of the sun and other planets; and it is by the same great forces that all the heavenly bodies that lie beyond our system are held in harmonious order, and, in all likelihood, in analogous fraternities. As the secondary planets revolve round their primaries, and these, again, round the sun, so the solar system itself may revolve round some vaster centre, and this order of things through systems and centres that baffle the grasp of our finite conceptions.

[Though the subject belongs properly to Astronomy, it may, for the sake of reference, be here stated that the solar system, as at present known, consists of the great centre, or *sun;* nine large or primary *planets* revolving round the sun in nearly circular orbits; seventy-one *planetoids,* or small planet-like bodies, between the orbits of Mars and Jupiter, and occupying, as it were, the place of a large primary; twenty secondaries, or *satellites,* revolving round their primaries; and an unknown number of *comets,* which move in extremely elliptical orbits, and consequently become visible to us only at widely-recurring periods. The subjoined table exhibits at a glance the names of the planets, their relative distances from the sun, the times of their revolutions and rotations, their velocities, and number of satellites:—

Names and Order of Planets.	Distance from Sun in Miles.	Time of Revolution in Days.	Velocity in Orbit per Hour.	Rotation in Days and Hours. D. H. M.	No. of Satellites.
SUN, . . .	...	...	17,583	25 0 0	...
Vulcan, . .	18,500,000	19.70	...	...	...
Mercury, . .	37,000,000	87.97	109,300	1 0 5	0
Venus, . . .	69,000,000	224.70	80,000	0 23 21	0
Earth, . . .	95,000,000	365.24	68,000	1 0 0	1
Mars, . . .	144,000,000	686.98	55,000	1 0 39	0
Planetoids, .	263,000,000	1,684.74	40,900	...	0
Jupiter, . .	494,000,000	4,332.62	29,800	0 9 56	4
Saturn, . .	906,000,000	10,759.30	22,000	0 10 29	8
Uranus, . .	1,822,000,000	30,686.82	15,500	0 9 30	6
Neptune, . .	2,869,000,000	60,624.63	12,400	...	1

12. The sun being the great centre of light, heat, and other ethereal influences, it necessarily follows that, during the earth's rotation on her axis, only one half of her surface can be exposed at a time to these influences, and hence the alternations of *day* and *night,* and all the phenomena that accompany these alternations. But day and night are of unequal and varying length at certain localities, according to the *seasons;* and these seasonal successions are caused by the facts—*first,* that the orbit or path of the earth's revolution round the sun is not a perfect circle, but an ellipse; and, *second,* that in performing this revolution her axis is not perpendicular, but inclined at an angle of 66 degrees 27¼ minutes to the plane of her orbit. The accompanying diagram will assist in explaining the consequences of this elliptical orbit and obliquity of axis. Thus S is Sun, with the earth represented at four different points in her annual orbit. At A and B the light and heat of the sun strike at the equator, or middle line, and consequently day and night are of equal duration. At any intermediate position, day and night are respectively lengthened and shortened: when at C, the north pole is in darkness; and when at D, the south pole is in the same

state. When the point presented to the sun is at *e* (which is on the 22d December), it is midsummer to all the southern parts of the earth, and winter to all the north; but as the exposed part advances towards the point *f*, the northern regions gradually re-



The Seasons.

ceive more and more heat, till, on the 21st of June, it becomes their midsummer. Having glanced at the main systemal motions of the earth that regulate our days, years, months, and seasons, we shall now advert to her own proper dimensions, as determined by the astronomer and mathematician.

13. The body which thus rotates on its own axis while it revolves round the sun, and is in turn revolved around by the moon, is not, strictly speaking, a sphere or globe, but a *spheroid* (Gr. *sphaira*, a globe; *eidos*, likeness), or body of a sphere-like form. A diameter taken along its axis, or the ideal line round which it rotates, is only 7899.170 miles, while one taken in the opposite direction is 7925.648 miles. The one diameter thus exceeds the other by about 26½ miles, thereby causing a deviation from the true globular form, and producing what mathematicians term an *oblate spheroid*—that is, a figure flattened in the direction of its axis, and bulging out all around somewhat in the shape of an orange. Such a figure can be readily produced by rapidly spinning a ball of yielding material (like soft clay or putty) round its own axis, when the tendency which all revolving bodies have to fly off from the centre (centrifugal force) causes the mass to bulge out at the rotating circumference and to flatten in proportion at either end of the axis. To this centrifugal force arising from rotation, and to some original yielding condition of the

earth's mass, is its oblate or spheroidal form usually ascribed. The earth's mass, as is well known, is kept together by the force of *gravitation;* and had it remained at rest, its form would have been perfectly spherical; but the moment it began to turn on its own axis, the particles of its mass began to obey another law—viz., that of *centrifugal force*, which exerts itself at right angles to the axis of rotation, and in proportion to the distance from that axis. Hence the greater bulging out of the earth's mass at the equator, where the distance from the axis is greatest; and hence also the gradual declension of centrifugal force as we proceed towards the poles. Gravitation and centrifugal force are thus the two great counteracting powers by which the earth is sustained in its present spheroidal form; and any variation in its dimensions, density, or velocity of rotation, would be accompanied by a proportional deviation from its existing form.

[It has been proved, we have said, by the astronomer and mathematician, that the true figure of the earth is that of an *oblate spheroid*, or ellipsoid of revolution; but of its *general spherical* or *globular form* the ordinary observer has many proofs, among which may be mentioned the following:—1. As a vessel sails away from the land, we first lose sight of her hull, next of her lower or main sails, and lastly of her topsails and pennants, thus clearly showing that she is passing over a convex or bulging surface. 2. The reverse of this also holds true; for the mariner, as he approaches the land, first sees the mountain-tops, and on gradually nearing it, the lower grounds stage by stage make their appearance. 3. Had the earth's surface been flat, it would have been all at once illuminated by the rays of the sun; but being convex or round, each place, as it turns from west to east, has its sunrise, noon, sunset, and night in succession—one half of the globe being thus always in light while the other is in darkness. 4. In travelling any considerable distance, either north or south, new stars gradually come into view in the direction to which the traveller is advancing, while others disappear in the direction from which he is receding. 5. Many navigators, by constantly sailing in one direction, or nearly so, whether due east or due west, have returned to the port from which they set out, thus making what is termed the *circumnavigation* of the globe. 6. In consequence of the round form of the earth, the dip or depression of the horizon is about 8 inches per mile, and on this account engineers in cutting canals have to make an allowance for a dip of this extent in order to keep the water at a uniform level. This dip increases, of course, as the square of the distance, and hence at three miles the depression will be nine times 8 inches, or 6 feet, and so on for every other distance. 7. The shadow which the earth casts on the moon during an eclipse is always circular. And, lastly, the earth belonging to a system or brotherhood, the other members of which are globular, the fair presumption is, that she also is of the same form.]

14. Calculating from the dimensions given in the preceding paragraph, the *mean diameter* of the earth will be 7912.409 miles, and its *mean circumference* or girth 24,858 miles. It is usual, however, to speak, in round numbers, of the diameter being 8000; the radius, or distance from the surface to the centre, as 4000;

and the circumference as 25,000 miles. The superficial area of a globe of these dimensions amounts to 197 millions of square miles; and of these about 51 millions consist of land, and 146 millions are occupied by water. The proportion of land to that of water may, therefore, be said to be, in round numbers, as *one* to *three;* or, in other words, while one-fourth of the earth's surface consists of dry land, the other three-fourths are covered by the waters of the ocean. This is not the place to inquire into the causes of this unequal distribution, or the purposes it was meant to subserve; but we may rest assured that it is the result of Design, and in necessary harmony with the higher and vital ordinances of nature. The *solid contents* of the mass have, in like manner, been computed to exceed 260 thousand millions of cubic miles—an amount which, though expressible in figures, is altogether beyond the grasp of human conception. It is enough, then, for the student to be convinced of the magnitudes of such amounts, without troubling himself with the remembrance of their numerical expressions.

[Though impossible to grasp the conception of the numerical amounts, we may here, for the sake of comparison, exhibit in tabular arrangement the diameters, solid contents, volumes, weight, and specific gravities of the several members of the solar system, as calculated by the astronomer and physicist:—

	Diameters in English Miles.	Solid Contents in Millions of Cubic Miles.	Volume, Earth being = 1.	Weight, Earth = 1.	Force of Gravity at Earth = 1.	Specific Gravity, Earth = 1.
Vulcan, .	785	....	....	....	....	....
Mercury, .	3,140	10,195	0.06	0.18	1.15	2.94
Venus, . .	7,700	223,521	0.96	0.90	0.91	0.92
Earth, . .	7,916	260,775	1.00	1.00	1.00	1.00
Mars, . .	4,100	48,723	0.14	0.15	0.50	0.95
Planetoids,	....	....	....	....	0.05	....
Jupiter, .	90,000	343,125,820	1,414.20	333.61	2.45	0.24
Saturn, .	76,068	245,089,877	734.80	101.78	1.00	0.14
Uranus, .	34,500	19,727,774	82.00	19.93	1.15	0.24
Neptune, .	42,000	....	150.00	31.79	1.20	0.23
Sun, . .	883,000	399,839,629,687	1,407,124.00	357,000.00	27.90	0.25
Moon, .	2,160	5,274	0.02	.0125	0.16	0.62

Density, Temperature, Atmosphere.

15. The density of the globe, as compared with the materials at its surface, has been determined with considerable precision. The average or mean density of the most prevalent rocks is about 2½ times that of water at the temperature of 62° Fahrenheit, while the

density of the whole mass, as determined by astronomical experiment, is 5½ times (5.675) that of water. It is evident from this that the interior of the earth cannot be composed of the same materials that constitute its outer portion; for these, under the law of gravitation, would be so compressed at the depth of a few miles as to give a greater mean density to the whole mass than its astronomical relations allow. Thus it has been calculated that air, at the depth of 84 miles from the surface, would become as heavy as water; that water, at the depth of 362 miles, would be as dense as quicksilver; and that the density of marble at the centre of the earth would be 119 times greater than what it is at the surface. Either, then, the interior of the earth is composed of materials differing altogether in nature from those known at its surface, or the compression of gravitation must be counteracted by some highly expansible force, such as heat, so as to maintain the mean density which astronomy and physics have determined. It is thus that geologists, and geographers adopting the language of geologists, speak of the "crust of the globe," and of the "interior of the globe"—meaning by the former that outer portion, composed of rocks and rock-masses, which can be observed and examined; and by the latter, that inner portion which is placed beyond such investigation, and respecting which we can offer little more than conjecture and hypothesis.

16. Closely connected with the density of the globe is its temperature, or the amount of heat that pervades it. As one of the orbs of the solar system, the earth has a variable, superficial, or atmospheric temperature; it has also a temperature peculiar to the rocky crust; and, judging from volcanic action, there is also a higher and more remarkable interior or central temperature. Respecting the *superficial temperature*, which constitutes the great theme of climatology, to be noticed hereafter (Chap. XII.), it may be stated, in the mean time, that it is influenced from day to day, and from season to season, by the heat of the sun; that it varies according to the latitude, being greatest at the equator, and gradually decreasing towards the poles; that it is greatly modified by the extent and distribution of sea and land—the sea and sea-coasts being more equable than inland continents, which experience extremes of heat in summer, and extremes of cold during winter; that it is also modified by the absorbent or radiating nature of the soil, according as this is dark or light-coloured, dry or moist, porous or compact; and, lastly, that it is notably affected by elevation above the mean level of the sea—the higher being the colder regions.

17. The *temperature of the accessible crust*, on the other hand, is affected either by the direct heat of the sun, by heat radiated

from the moon, by heat generated chemically among its own materials, or by heat derived by conduction from the interior. During summer, for instance, the earth is warmed to a certain depth by the heat of the sun; during winter this heat is given off to the surrounding atmosphere; and though the heat of one summer and the cold of one winter may differ from the heat and cold of others, still, on an average of seasons, the results are pretty equable. It may, therefore, be stated in general terms, that in summer the crust of the earth, at small depths, is colder than at the surface; that during winter the crust at these depths is warmer than at the surface; but that, at the depth of 80 or 90 feet, the variations of summer and winter become wholly insensible. As to the amount of heat generated within the crust by chemical, electrical, and magnetic forces, we have no accurate knowledge; but to these forces, as well as to conduction from the interior, may safely be ascribed the higher temperatures experienced in mines, wells, and other deep-seated situations.

18. Respecting the *heat of the interior*, we see it abundantly manifested in hot springs, volcanoes, and the like; and have by direct experiment been enabled to arrive at some important facts relative to its descending rate of increase. Thus it has been found by experiments in coal-pits, Artesian wells, and metalliferous mines, that, after passing the depth at which the surface-heat is inappreciable, the temperature begins to rise, and this gradually and steadily for every fathom of subsequent descent. Reckoning this "stratum of invariable temperature" at from 60 to 90 feet below the surface, according to the nature of the soils and rocks passed through, a rise of 1 degree of Fahrenheit takes place for every 60 feet of further descent; and calculating at this rate of increase, a temperature (2400° Fahr.) would be reached, at a depth of 25 miles or thereby, sufficient to keep in fusion such rocks as basalt, greenstone, and porphyry. At the same rate of increase, or even admitting, as some contend, that the thermometer only rises 1 degree for every 90 feet of descent, we would, at the depth of 150 miles or thereby, arrive at such a temperature that even the most refractory rock-substances would be dispersed before it like vapour. We know little, however, of the deportment of heat under such a pressure as must exist at these depths, and can only indicate the line of reasoning that leads to the general belief that the solid or rocky crust forms but a comparatively thin film, and that the great interior mass exists in a state of high incandescence or molten fluidity. Intense as this interior heat may be, and active as it undoubtedly is in the production of volcanic phenomena, the surface temperature of the globe is scarcely, if at all, affected by

it (according to Fourier, only $\frac{1}{17}$th of a degree), owing to the weak conducting properties of the rocky crust.

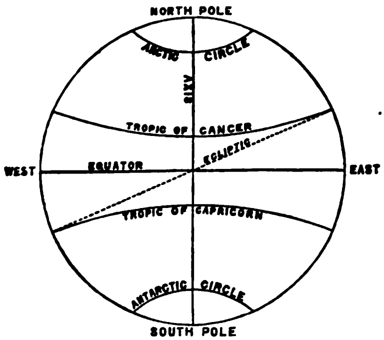
19. Besides these original conditions of form, size, motions, density, and temperature, there is also that of its atmosphere or aërial envelope that surrounds it on every side, and becomes an integral and indispensable portion of its constitution. This atmosphere, as is well known, is mainly composed of two gases, nitrogen and oxygen—79 parts of the former to 21 of the latter—with a small percentage of carbonic acid and other extraneous impurities. As at present constituted, the air is indispensable to vegetable and animal life; both alike breathe it, and by this breathing the functions of vitality in both are alike sustained. But while it is inhaled by both, animals exhale carbonic acid, and carbonic acid is inhaled and assimilated by plants, which in turn exhale oxygen, and thus the equilibrium or balance is restored and perpetuated. Being an elastic or compressible medium, the air nearest the sea-level is denser than that at considerable elevations; and by calculating the rate at which this rarity takes place, it has been estimated that, at the height of 45 miles above the sea, the atmosphere becomes so rare or light as to be inappreciable. We have thus, surrounding the earth, and partaking in all its movements, a gaseous envelope or atmosphere, whose pressure at the sea-level is estimated at 14¾ lb. avoirdupois on every square inch of surface, but which gradually becomes lighter and lighter, or more attenuated, as we ascend, till, at the height of 45 or 50 miles, its presence is inappreciable. The weight of the atmosphere is generally estimated as equal to the weight of a column of mercury 30 inches in height, or to one of water 34 feet in height; and as there are 14.7304 lb. avoirdupois on the square inch, the reader can easily imagine the enormous pressure exerted on the almost innumerable square inches of the earth's surface by this thin elastic medium, which is usually regarded as the type of lightness and rarity. Through this envelope the heat and light of the sun are equally diffused and modified; it is also the recipient and diffuser of all watery vapours arising from the earth; and from local alterations in its density or expansibility, caused by heat and the like, arise all aërial currents or winds, whether steady and regular, or fitful and irregular. The atmosphere is thus the grand medium through which light, heat, moisture, and other vital influences are communicated to the plants and animals that adorn the earth's surface; it is also the great laboratory in which all meteorological and electrical phenomena are elaborated; and hence all the varied aspects and results of winds, clouds, rains, snow, hail, thunderstorms, and the like, that constitute the essentials of climatic diversity.

Technical Subdivisions—Points, Circles, Zones, &c.

20. In treating of the earth thus constituted and surrounded, geographers make use of certain terms and technicalities expressive of distance, position, and the like, on its surface, and with these it will be necessary for the student, at this stage, to render himself familiar. Thus, the direction from which the earth moves in its daily rotation is called the *West;* that towards which it moves, the *East;* the point to which a spectator looks, with the east on his right hand and the west on his left, is called the *North;* and that behind him the *South.* In this rotation from west to east, any point on the earth's surface turns towards the sun in the morning, and away from him after mid-day; and thus the terms *Sunrise* and *Sunset* (the sun being a stationary centre) express not real, but merely apparent phenomena. The imaginary line on which the earth rotates is termed its *Axis*, and the terminations of this axis its *Poles*—that towards the north being known as the *North Pole*, and that towards the south the *South Pole.* From an idea of the early geographers, who were inhabitants of the northern hemisphere, that the north pole was uppermost (though in reality there can be neither upper nor under in a globe freely rotating in space), it is customary in our maps and charts to place the northern part at the top, and the southern at the bottom, with the east on the right hand and the west on the left. A line distant alike from either pole, and dividing the earth into two equal portions (Lat. *æquus*, equal), is called the *Equator;* the northern half being known as the *Northern Hemisphere*, and the southern as the *Southern Hemisphere.* In the same way we may speak of the *Eastern Hemisphere* and *Western Hemisphere*, by supposing the globe divided by a line passing through the poles, and thus necessarily cutting the equator at right angles. Reckoning London as a fixed point on such a line, Europe, Asia, and Africa will lie in the eastern hemisphere, and North and South America in the western. (Map, page 49.)

21. Like other circles, the circumference of the earth is divisible into 360 equal parts or *degrees*, and in this case each degree will equal about 69.05 British statute miles. At the distance of 23½ degrees north and south of the equator, as shown in the accompanying diagram, are two parallel lines called the *Tropics* (Gr. *trope*, a turning), from their marking the turning-points of the sun in the ecliptic; that on the north being known as the *Tropic of Cancer*, and that on the south as the *Tropic of Capricorn*, because these constellations occupy a corresponding part in the heavens. At the same distance (23½ degrees) from either pole is a

parallel line—that on the north being called the *Arctic Circle* (from the northern constellation, *Arctos*, the Bear), and that on the south the *Antarctic Circle*, because opposite (*anti*, opposite) to that of the north. The space or belt between the tropics is called the *Torrid Zone*, because the sun, being always vertical in some part of that space, produces a greater degree of heat than in regions where his rays strike more obliquely. The spaces between the tropics and the Arctic and Antarctic Circles, on either side, are termed the *Temperate Zones* (north and south); and those between these circles and their respective poles the *Frigid Zones*. The breadth of each of the torrid zones is therefore about 1622½ statute miles;* of each of the temperate, about 2969; and of each of the frigid, 1622½ miles. Or, calculating their areas in square miles, the earth's superficies is made up nearly as follows:—



Zones and Circles.

North Frigid Zone, . .	8,132,797	square miles.
North Temperate Zone, .	51,041,592	,,
Torrid Zone, ...	78,314,115	,,
South Temperate Zone, .	51,041,592	,,
South Frigid Zone, . .	8,132,797	,,

It is customary for the botanist and zoologist to subdivide those zones more minutely into equatorial, tropical, sub-tropical, warm-temperate, cold-temperate, sub-arctic, arctic, and polar; but of these subdivisions and their characters when we come to treat of the distribution of vegetable and animal life.

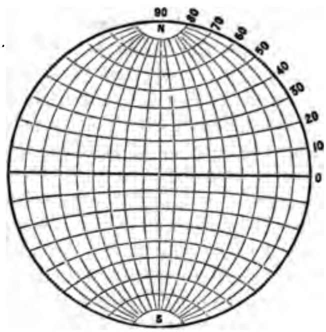
22. The equator has been already described as a circle exactly between the poles, and cutting the globe into two equal portions. A line which cuts the equator obliquely, and touching upon opposite sides of the tropics, is called the *Ecliptic* (Gr. *ekleipsis*, an eclipse). The ecliptic is the orbit described apparently by the sun round the earth, but in reality by the earth round the sun, and is named from the circumstance that all eclipses can happen only when the

* The length of a British statute mile is 1760 yards, or 5280 feet; while a geographical mile is 2028.92 yards, or 6086.76 feet.

moon is on the same plane, or very near it. The points where the ecliptic cuts the equator are called the *Equinoctial Points* or *Nodes*, because when the sun is in these parts of his course, the day and night are of equal duration. These equinoxes take place twice a-year—namely, on the 21st March and 21st September. The term *Greater Circles* is sometimes applied to the equator and ecliptic, because they encircle the earth at the thickest part, or form planes that pass through its centre; and that of *Lesser Circles* to the tropics, arctic and antarctic circles above described. Besides these circles, another set of lines, drawn from pole to pole over the earth's surface, and cutting the equator at right angles, are termed *Meridians* (Lat. *meridies*, mid-day), because when any of these lines is opposite the sun it is mid-day, or twelve o'clock, with all the places situated along that meridian on the same side of the globe, while on the other side it is midnight. When it is noon, for instance, in any particular part of Britain, it is midnight at an opposite and corresponding point near New Zealand, and so on for the intermediate hours at directly opposite parts along the same meridian. Thus, diametrically opposite points on the globe are said to be the *Antipodes* of each other (Gr. *anti*, opposite, and *pous*, *podos*, foot), because the feet of their inhabitants are placed, as it were, in opposition to each other.

23. The position of a place on the earth's surface is determined by what is termed its *Latitude* and *Longitude*. The latitude of a place is its distance north or south from the equator; hence we speak of north latitude (N. Lat.) in the northern hemisphere, and of south latitude (S. Lat.) in the southern hemisphere. Longitude, on the other hand, is measured east and west of any fixed meridian — different countries adopting different meridians (usually that of their capitals), and Britain that of the Royal Observatory at Greenwich; hence English geographers speak of east longitude (E. Long.) and west longitude (W. Long.), according as a place may be situated eastward or westward of the meridian of Greenwich. The terms *longitude* and *latitude* arose from a notion of the ancients that the earth was longer from east to west than from north to south; in other words, that it had *length* (longitudo) and *breadth* (latitudo)—an idea which is thereby most conveniently expressed. The circles on the earth being divided into 360 degrees, and each degree again into 60 minutes, each minute into 60 seconds, and so on, the position of a place can be indicated with great precision; and for the sake of brevity certain signs are employed, as $4° 6' 12''$, meaning thereby 4 degrees, 6 minutes, and 12 seconds. The distance between the equator and either pole

being only the fourth part of the earth's circumference, the latitude of a place north or south of the equator can never exceed the fourth part of 360, or 90 degrees. Longitude, on the other hand, being measured east and west of a fixed meridian, embraces a whole hemisphere, or 180 degrees; and as the meridians all converge towards the poles, the degrees of longitude become less and less as we approach these extremities. The lines of latitude being necessarily parallel to each other, geographers speak of *parallels of latitude*, designating those that lie near to the equator as *low* latitudes, those that approach the poles as *high* latitudes, and those that intervene as *middle* latitudes.



Parallels and Meridians.

[It has been stated above that the value of a degree of longitude varies according to the latitude, being equal to a degree of latitude at the equator, but gradually becoming less as we approach the poles. The following table exhibits this diminution for every 5 degrees of latitude both in geographical and British statute miles:—

Degree of Latitude.	Geographical Miles.	English Miles.	Degree of Latitude.	Geographical Miles.	English Miles.
0	60.00	69.07	50	38.57	44.35
5	59.77	68.81	55	34.41	39.58
10	59.09	67.95	60	30.00	34.50
15	57.95	66.65	65	25.36	29.15
20	56.38	64.84	70	20.52	23.60
25	54.38	62.53	75	15.53	17.86
30	51.96	59.75	80	10.42	11.98
35	49.15	56.51	85	5.23	6.00
40	45.96	52.85	90	0.00	0.00
45	42.43	48.78			

NOTE, RECAPITULATORY AND EXPLANATORY.

In the foregoing chapter we have noticed those primary conditions of form, motion, size, density, temperature, and the like, which belong to the earth as a member of the solar system These conditions lie, as it were, at the foundation of all change and diversity on the earth's surface—day and night, heat and cold, summer and winter, meteorological fluctuation and climate, oceanic tides and currents, geological waste and reconstruction, and, in fine, all that confers diversity on land and water, and consequently on vegetable and animal life, being directly or remotely dependent on the original constitution of the globe, and its connection with the solar system. It is necessary, then, that the student should render himself familiar with the planetary relations of the earth—its spheroidal form, its daily and annual revolutions, its density, temperature, magnitude, and admeasurements, as well as with those terms and technicalities by which its several portions and positions are known and described. As an oblate spheroid, then, the earth has an equatorial diameter of 7925.648, and a polar diameter of 7899.170 miles (or, according to the mean of measured meridional arcs, 7926.05 and 7899.6), rotates on its own axis in 23 hours, 56 minutes, and 4 seconds, or in one *day;* revolves round the sun in an elliptical path or orbit in 365 days, 5 hours, 48 minutes, and 50 seconds, or one *year;* and is in turn attended by the moon, which performs her revolution in 27 days, 8 hours, or one lunar *month.* As the mean circumference of the earth is 24,858 miles, and as she rotates on her axis once in 24 hours, it is clear that any spot on the equator must be borne round at the rate of more than 1000 miles an hour. With every successive removal from the equator, however, the circles of latitude become smaller and smaller, and as they are all carried round within the same period of 24 hours, their rate of motion must be proportionally less. At the 60th parallel, for example, this motion is only 500 miles an hour, and at the absolute poles it ceases to exist. The mean density of the rocks known at the surface of the earth is about 2½ times that of water, while that of the entire mass is 5½, thereby showing that the interior consists of different material, or of materials in a different condition from those in its rocky crust. The earth's own proper temperature, as distinct from that received by its atmosphere and surface from the sun, increases according to the depth, and this increasing temperature is apparently the cause of volcanoes, hot springs, and other thermal phenomena. The increase being at the rate of 1 degree Fahr. for every 60 feet of descent or thereby, the deeper-seated portions must be in a state of high incandescence, or, at all events, in a condition very different from the solid rocks that constitute the outer crust; but these rocks being bad conductors of heat, the surface temperature, it is calculated, cannot be affected by the internal heat beyond the merest fraction of a degree. The earth is also surrounded by an aërial envelope or atmosphere, consisting in the main of 79 parts nitrogen and 21 oxygen, with a fractional percentage of carbonic acid; and this gaseous envelope, being an elastic medium, is denser at the earth's surface (where it presses with a weight of 14¾ lb. on the square inch), and becomes rarer and rarer as we ascend in space, till at the height of 45 or 50 miles its presence becomes inappreciable. This atmosphere is the medium through which the sun's light and heat are equally diffused; the laboratory in which all meteorological phenomena—winds, rains, clouds, storms, &c.—are elaborated; and, in fine, the source whose varied mutations are the proximate causes of all climatic diversity. In treating of the earth, various terms and technicalities are necessarily employed by geographers, and with these the student should early render himself familiar. Thus, the imaginary line on which the earth turns in her daily rotation from west to east is termed the *axis;* the extremities of this axis, north and south, the *poles;* the *equator,* the circle between the two poles which cuts the globe into two equal portions or *hemispheres;* the *torrid, temperate,* and *frigid zones,* the varying belts of surface temperature as we proceed northward and southward from the equator, where the sun's heat is greatest; the *ecliptic,* the apparent path of the sun round the earth; *meridians,* those lines drawn from pole to pole over the earth's surface, and at right angles to the equator, along which the sun is vertical at his highest daily ascension or *noon; latitude,* the distance of any place, measured in degrees, north or south of the equator; and *longitude,* the distance of the same place east or west from any arbitrary or convenient meridian—that in Britain being the meridian of Greenwich; that in France, Paris; and that in Germany, the Faroe Islands.

To the student who wishes to enter more minutely into the consideration of the earth's planetary or astronomical relations, we may recommend persual of Sir J. Herschel's 'Outlines of Astronomy,' Mr G. D. Chambers's 'Handbook of Descriptive and Practical Astronomy;' and Mrs Somerville's 'Connection of the Physical Sciences.' For a fuller explanation of the technical terms of his science, he may consult the *Glossary* appended to the present volume.

III.

THE EARTH—ITS INDIVIDUAL STRUCTURE AND COMPOSITION.

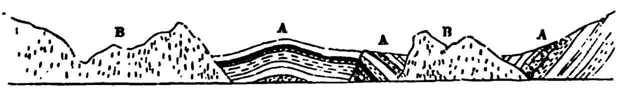
The Rocky Crust—Its Constitution and Formation.

24. HAVING considered in the preceding chapter some of the more obvious relations of the globe as a member of the Solar system, and the terms usually employed to express their connections, we now proceed to describe the leading features of its own special structure. As the knowledge of its general relations was derived chiefly from Astronomy, so a knowledge of its individual structure is mainly obtained from the teachings of Geology. As the one set of facts could be taught without going deeply into the problems of the astronomer, so the other may be understood without entering largely into the reasonings of the geologist. What, for instance, is the nature of the earth's rocky crust? How are its rocks arranged, and how does this arrangement affect its superficial character? What has stretched out the level plain and upheaved the rugged mountain? What renders one soil obnoxious and sterile, and another genial and fertile? And as the earth's crust is continually undergoing modification under the operations of external and internal forces, what the effects of such modifications on the general geography of the globe? These and similar problems geology endeavours to solve, and, with a little explanation, these solutions may be rendered intelligible to the student of Physical Geography.

25. Geologists speak of the "crust of the globe" just as the housewife talks of the "crust of her loaf." The crust of the loaf is one thing, the inside of it another. The crust or exterior portion of the earth, composed of rocks and rock-materials that can be seen and handled, is one thing; the interior, of which we can know nothing by direct observation, may be, and in all likelihood is, a very different thing. By observation and comparison we can determine a great many truths respecting the structure and composition of the one; respecting the other we can offer at best

little more than conjecture. This outer portion or rocky crust is the great theatre of all geographical phenomena—the foundation of the land and waters—the arena of climatic influences—the field of vital development; and, as such, it behoves the geographer to know something of its history and constitution. That history, as geology has taught us, is a long and varied one; that constitution, as bearing more immediately upon the problems of geography, we shall endeavour briefly to explain.

26. On the most cursory inspection of quarries, railway-cuttings, sea-cliffs, and ravines, the observer will find a great portion of the rocks arranged in layers, or lying one above another in beds or strata (Lat. *stratum*, spread out). These are said to be *stratified*, and generally consist of sandstones, clays, shales or consolidated muds, limestones, and other similar rocks. He will also find another set not spread out in layers, but rising, hard and massive, in no determinate arrangement. These are termed the *unstratified*, and consist of such rocks as the granites, greenstones, basalts, and lavas. How, he will naturally inquire, have two sets of rocks so dissimilar in character and arrangement been produced? And as we can only interpret nature's productions by a knowledge of nature's operations, we must seek for the answer to this question in what is now taking place around us. And first, if we turn to any lake, estuary, or bay of the ocean, we will find that the mud, sand, and gravel carried down by the rivers or washed from the cliffs by the waves and tides, are deposited and arranged along the bottom of these receptacles in layers or strata more or less horizontal, and in course of ages one above another, precisely like the shales and sandstones of the quarries and sea-cliffs. Here, then, we are entitled to infer that rocks arranged in layers or strata have been formed through and by the agency of water (Lat. *aqua*); that is, have been deposited as sediment (Lat. *sedere*, to settle down) in water, or brought together and assorted by the action of moving water; and hence they are termed *aqueous*, *sedimentary*, or *stratified*.



A A A, Stratified; B B, Unstratified Rocks.

If we turn, in the next place, to the volcano or burning mountain, we find that lava and other molten rock-matters are discharged from its crater; and these, when cooled and consolidated age after age, form mountain-masses, and fill up chasms and rents produced by earthquakes, precisely as the granites and greenstones and basalts do among the stratified rocks with which they are associated. Here, again, we are entitled to infer that the greenstones, basalts, and other similar rocks are the products of fire (Lat. *ignis*, fire), and hence they are designated *igneous*, *eruptive*, or *unstratified*.

27. In the crust of the earth, then, we have two main sets of rocks—the stratified and the unstratified; the one formed through and by the agency of water, the other through and by the agency of fire. The former are chiefly the products of aqueous and atmospheric waste, the latter the products of igneous reconstruction; and between these two forces, the aqueous and igneous, the crust of the earth has ever been held in habitable equilibrium. Were the aqueous and atmospheric forces to operate uncontrolled, all the higher portions of the dry land would in the course of ages be worn down, and the whole reduced to a dreary uniformity of level; but, to prevent such a contingency, the volcanic forces are perpetually exerting themselves from below, and once more upheaving the crust into dry land and diversity of surface. What the frosts and rains and rivers are wearing and carrying from the higher lands is deposited in layers of mud, sand, and gravel in the lakes and estuaries below; and what is wasted from the sea-cliffs by waves and tides is borne along and distributed in the bays and other sheltered recesses of the ocean. These deposits, in course of time, become consolidated, by pressure and internal chemical changes, into shales and sandstones and conglomerates; and we can readily conceive the low, level, superficial aspect of a globe where this sedimentary process went on unchecked for ages. But the forces from within are as incessantly at work as the forces from without, and sooner or later (according to some law whose order is yet unknown) these strata are upheaved into dry land, with all that diversity of surface which seems inseparable from the efforts of the earthquake and volcano. The great design of creation seems clearly to be diversity in time as well as diversity in space. Whether under the open air or under the waters of the ocean, hill and dale, level plain and rugged mountain, are ever attended by diversity of soil, diversity of winds and currents, heat and cold, and all the other climatic influences on which diversity of plant-life and diversity of animal life are so intimately dependent. To the primary geological oscillations of the earth's crust are we, therefore, indebted for all that confers on its surface geographical variety and diversity; and hence the value of some knowledge of geology to him who would thoroughly comprehend the existing aspects of nature.

Relative Age and Arrangement of Rock-Formations.

28. If, then, the crust of the globe be in a state of oscillation between the aqueous and atmospheric forces that waste and wear from without, and the igneous forces that reconstruct and upheave from within—if cliffs and hills are worn down, and lakes and estuaries filled up and converted into alluvial plains—if plains are thrown up into mountains, and the sea-bed into dry land—if large tracts of the earth are gradually raised higher and higher above the ocean, while other regions are gradually submerged—it is clear that different portions of the rocky crust must be of different ages, and composed of different materials. The present distribution of sea and land has undergone many noted modifications even within the historic era; and if such changes have been accomplished within a period so brief as a few thousand years, what may we believe to have taken place during the thousands of ages that preceded human history? So numerous have been these changes, as clearly demonstrated by geology, that every portion of the existing dry land has been repeatedly beneath the waters; and that which now constitutes the bed of the ocean, has in like manner been the dry land of former epochs.

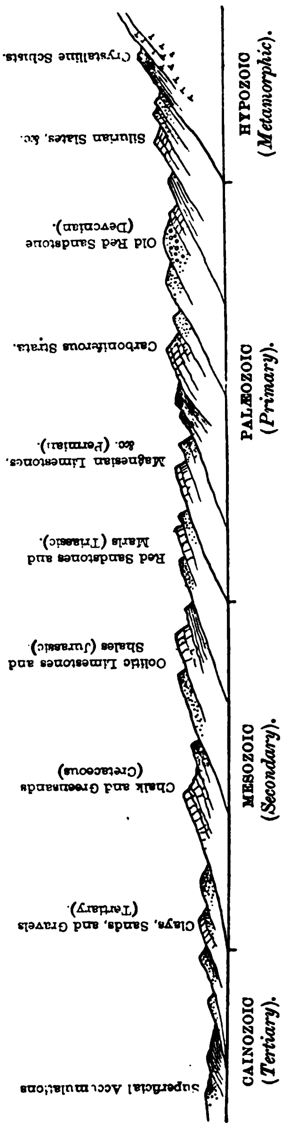
> "There rolls the deep where grew the tree;
> Oh, Earth, what changes hast thou seen!
> There, where the long street roars, has been
> The stillness of the central sea.
>
> The hills are shadows, and they flow
> From form to form, and nothing stands;
> They melt like mists, the solid lands—
> Like clouds, they shape themselves and go!"

The record of these changes lies in the stratified rocks, each period producing its own sedimentary deposits, and these deposits constituting what geologists term a *formation*, as having been formed at a certain period, and under the peculiar conditions of that period. Farther, as the sediments of existing lakes and estuaries and seas imbed the remains of plants and animals that have lived in these areas, or have been drifted from the land—leaves, branches, trunks, bones, teeth, shells, and crusts; so the sediments of former ages contain the remains of plants and animals that then existed—these remains being petrified, or converted into stone. These petrifactions, or *fossils*, as they are termed, differ widely in many instances from the plants and animals now peopling the globe; and this difference may be said to increase with the depth and age of the strata that contain them. As a general rule, the older strata will be the deepest seated; the older, harder and more crystalline than the recent and superficial; and the older the strata, the greater will be the difference between their fossil plants and animals and the plants and animals now existing. Founding on principles such as these, geologists have arranged the stratified rocks into formations and systems according to their relative antiquities—each division representing (as nearly as can be determined) a different arrangement of sea and land, and a different aspect of vegetable and animal life during the period of its deposit.

29. Thus, beginning at the recent and superficial, which contain few extinct forms of life, and descending through systems whose fossils belong chiefly to extinct races, we have:—

Systems.	*Periods.*
1. POST-TERTIARY or RECENT ACCUMULATIONS. 2. TERTIARY SYSTEM.	CAINOZOIC (*Recent Life*).
3. CRETACEOUS or CHALK SYSTEM. 4. OOLITIC or JURASSIC SYSTEM. 5. TRIASSIC or UPPER NEW RED SANDSTONE.	MESOZOIC (*Middle Life*).
6. PERMIAN or LOWER NEW RED SANDSTONE. 7. CARBONIFEROUS SYSTEM. 8. DEVONIAN or OLD RED SANDSTONE. 9. SILURIAN and CAMBRIAN.	PALÆOZOIC (*Ancient Life*).
10. METAMORPHIC or CRYSTALLINE STRATA.	HYPOZOIC (*Beneath Life*).

Or, arranging them in diagrammatic form, as they occur in the British Islands, we have the intelligible representation that appears on the following page. It is not asserted that these rock-formations and systems occur in full and regular succession in every part of the world, but merely that such is their order in time wherever they have been examined by the geologist. The Old Red Sandstone or the Carboniferous system may occupy the whole surface of a country without any of the newer systems being present, just as the Chalk or Oolite may be the surface rock, without having the whole of the older strata below; but the oolite never occurs above the chalk, nor the old red sandstone above the coal. The order of their succession is fixed and determinate, and each system represents a portion of time as well as a series of rocks—a portion of time in world-history, just as certain reigns and dynasties and nationalities represent successive stages in the history of the human race:—

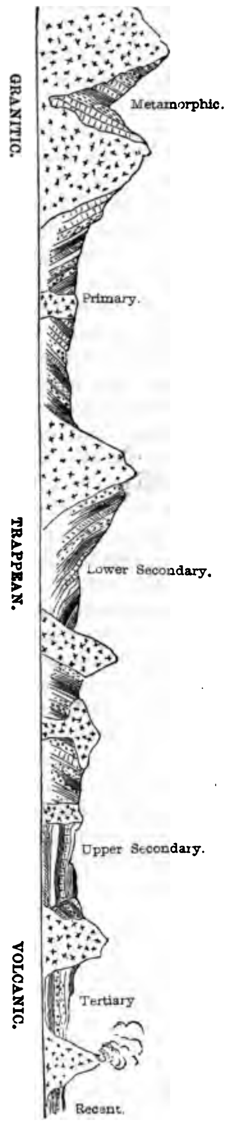


CHRONOLOGICAL SUCCESSION OF BRITISH STRATIFIED SYSTEMS.

30. As the stratified rocks have been arranged in chronological sequence, so also the unstratified or igneous admit of a similar, though less precise, arrangement. As at present, so during every former epoch of the earth's history, the volcanic forces have been in a state of activity—breaking up the stratified crust, throwing out lava and other products in the formation of hills, and filling up earthquake-fissures with molten rock-matter from below. In course of the earth's mutations these earlier products become submerged beneath the waters of the ocean, and overlaid by newer sedimentary deposits, again to be broken through by another set of igneous operations, and this consecutively and continuously from the most distant ages up to the present day. As a general rule, the earliest igneous rocks will be associated with the earliest stratified deposits, and the older and deeper-seated will be more uniform and crystalline in texture than the newer and more superficial. Founding on principles such as these, geologists usually arrange the igneous or unstratified rocks in the following chronological order:—

1. **Volcanic, associated chiefly with Tertiary and Upper Secondary strata.**
2. **Trappean, associated chiefly with Secondary and Upper Primary strata.**
3. **Granitic, associated chiefly with Primary and Metamorphic strata.**

Or, arranging them diagrammatically with the stratified systems, we have something like the annexed connection:—



GENERALISED ARRANGEMENT OF STRATIFIED AND UNSTRATIFIED ROCKS.

31. The consideration of these systems and subdivisions forms the special subject of geology; but as each formation occupies a distinct portion of the earth's crust, consists of different kinds of rocks, and presents different soils and surfaces to the geographer, it may be of use briefly to epitomise:—

1st. That the *Post-tertiary System* consists in the main of clays, gravels, sands, peat-mosses, marls, coral-reefs, and other superficial accumulations that have been formed in ancient lake-basins, river-valleys, estuaries, and shallows of the ocean, within a comparatively recent period. They imbed, in a sub-fossil state, the remains of plants and animals still existing, but frequently removed from, or extinct in, certain localities which they once inhabited. In volcanic districts they are associated with recent lavas, scoriæ, and similar products; and, generally speaking, they occupy low-lying tracts, and constitute the surfaces of valleys, plains, and other alluvial expanses. Associated with these superficial accumulations, but for the most part lying beneath them, there occur all over the northern hemisphere thick deposits of clay and gravel imbedding huge water-worn blocks or *boulders;* and as these seem to point to a time when large areas of the northern hemisphere were under ice, or subjected to the drift of icebergs that dropped their burdens of clay, gravel, and boulders on the then submerged surface, this period is generally known as the

Boulder, *Northern Drift*, or *Glacial epoch*, and holds a place intermediate between the Post-tertiary and true Tertiary systems.

2d. The *Tertiary System* consists, in general terms, of clays, gravels, sands, limestones, marls, and lignites or beds of wood-coal; and occupies well-defined areas, as if these at one time had been extensive fresh-water lakes, estuaries, and inland seas. The fossils imbedded in tertiary strata, though closely allied to existing genera and species, are in many instances extinct (especially the gigantic quadrupeds, which is one of its characteristic features), and point to conditions of climate and distributions of life very different from those at present prevailing. The igneous rocks associated with them are lavas and basalts, the products of volcanoes, long since extinct, or now but partially active. Undulating lowlands may be said to constitute the physical features of tertiary districts—the pampas of Buenos Ayres, and the basins of London, Paris, and Vienna, being typical examples.

3d. The *Cretaceous* or *Chalk System* (Lat. *creta*, chalk) consists, as its name implies, of thick beds of chalk or soft marine limestones, associated with sands, sandstones, clays, and in some localities with beds of coal and lignite. The fossils belong almost wholly to extinct species; and even where the chalk beds are wanting, the other strata are so replete with their characteristic marine remains, that there is generally little difficulty in recognising the system. The associated igneous rocks are chiefly basalts and greenstones; and the physical features of the system may be said to be low rounded hills, with dry intermediate depressions, where the chalk and sands prevail, and flat fertile vales, where the rich organic clays come to the surface.

4th. The *Oolitic* or *Jurassic System* consists largely of limestones, alternating with calcareous clays and sandstones, bituminous shales, and occasional beds of ironstone and coal. It derives its former name from its peculiar limestones or roestones (Gr. *oon*, egg; *lithos*, stone), which consist in many instances of rounded grains like the roe of a fish; and its latter from its abundant development in the Jura Mountains. As a system, it occurs in many parts of the world, and is characterised by its abundant marine remains, land plants of sub-tropical growth, and especially by the profusion of large nautilus-like shells (*Ammonites*) and gigantic land and water reptiles. The unequal wasting of its harder limestones, and softer clays and shales, confer on the oolitic landscape an agreeable succession of easy undulations; and unless where thrown up into higher hills by volcanic forces, this gradual alternation of hill and dale is the characteristic geographical feature of the system.

5th and 6th. The *Triassic* and *Permian Systems*, which were formerly considered as one great formation under the name of the *New Red Sandstone*, consist in the main of soft reddish sandstones, yellowish magnesian limestones, and variegated clays and marls, with occasional deposits of rock-salt. The lower portion, being largely developed in Perm in Eastern Russia, has given rise to the term Permian; and the upper, consisting in Germany of three well-marked members (sandstones, limestones, and marls), has received the name of Trias, or triple group. The fossil remains of these systems are chiefly marine, with footprints of birds and amphibious reptiles. The physical features of the new red sandstone are by no means decided—the limestones and harder sandstones forming inconspicuous hills and ridges, the softer clays and marls being worn into vales of a flat, wet, and retentive character.

7th. The *Carboniferous System*, so called from its yielding the main supply of coal (Lat. *carbo*, coal) in Europe and America, consists of sandstones, shales, clays, limestones, ironstones, and coals in frequent alternation, as if they had been deposited for ages in seas and estuaries, subjected to repeated subsidences and elevations. The fossils of the system are abundantly marine, estuarine, and terrestrial—the most notable being that excess of vegetable growth that went to the formation of numerous seams of coal. Belonging to the Palæozoic or far-back ages of the world, these remains have but little relationship to existing genera and species, and the highest known forms are merely fishes and reptiles—no bird or quadruped having yet been detected beneath the new red sandstone. With the exception of the trap hills (greenstones, basalts, tufas, &c.) that intersect the system in some localities, and those bold cliffs and scars of limestone (mountain limestone) so characteristic of Yorkshire and Derbyshire scenery, there is little attractive in the physical features of the coal-formation, monotonous moorlands of cold retentive soil being a common occurrence in the geography of the system. Like all the older systems, however, it is rich in mineral and metallic products—coal, lime, iron, lead, zinc, silver, and antimony being among its most important contributions to modern industry and civilisation.

8th. The *Old Red Sandstone* or *Devonian System* (from Devonshire, where a portion of it is typically developed) consists in the main of red sandstones, conglomerates, and shales, with subordinate beds of limestone. It abounds in ordinary marine fossils—corals, shells, crustacea, and fishes; but no higher life than fishes has yet been discovered in its strata, and its vegetable remains are, on the whole, very scanty and imperfect. Thrown into many irregularities by trap eruptions, the physical features of the old red sandstone are often varied and picturesque, and in general its slopes are dry and of moderate fertility.

9th. The *Silurian System* (so called from its typical development in that district of Wales anciently inhabited by the Silures) consists of numerous slaty or hard shaly beds, with sandstones, conglomerates, and intercalated limestones. As in all the older and deeper-seated rocks, there is often a tendency to crystalline structure among its strata, and these are not unfrequently traversed by metalliferous veins—tin, copper, silver, and gold. Its fossils are eminently marine, and consist almost wholly of the lower or invertebrate orders (corals, shellfish, and crustacea), few fishes being found in its strata, and these only in the upper portions of the system. Flanking and often borne up by the older granitic hills, the physical features of the formation are frequently irregular and mountainous, but, from the softer nature of the rocks, are more rounded and massive, and less abrupt and precipitous, than those of the crystalline or metamorphic system.

10th. The *Metamorphic System* (so called because its strata have undergone a metamorphism or change by heat, pressure, and chemical change, from ordinary sandstones, shales, and limestones into hard crystalline schists), consists of such rocks as gneiss, quartz-rock, mica-schist, clay-slate, and primitive marbles. They yield no fossils; but whether all traces of life may have been obliterated by the mineral change these rocks may have undergone, or whether they were deposited before life existed on the globe, Geology cannot determine, and merely expresses the fact by the term *Hypozoic*, which signifies lying beneath the strata that are decidedly fossiliferous. These crystalline schists are generally found at high angles, flanking or composing the main mass of the older mountains; and from their hard splintery nature present those peaks and ridges that confer on primitive districts their bold, wild, and alpine character.

32. Such are the leading features of the stratified systems, and by such, with a little field-practice, they may be readily detected in the various areas they occupy. As with the stratified so with the unstratified, each great group has its own peculiar features, and though perhaps less sharply defined, they are still sufficiently distinct to be recognised in hill and mountain ranges as volcanic, trappean, and granitic :—

1st. The *Volcanic*, as already stated, are generally associated with the more recent formations, and consist of trachytes, basaltic lavas, vesicular lavas, scoriæ, and other similar products—loose and less consolidated in the more recent and active, and harder and more compact in the older and extinct volcanoes. They rise up in dry rocky hills, more or less conical and crateriform; and these are, perhaps, more frequently grouped round some common centre than arranged in linear or axial directions.

2d. The *Trappean*, so called from the terraciform aspect of many of the hills they compose (Swedish, *trappa*, a stair), consist of greenstones or whinstones, basalts, felstones, porphyries, tufas, and other kindred rocks, and are generally associated with the secondary and upper primary strata. They are usually arranged in hill-ranges more or less persistent, and from their higher antiquity and longer subjection to wasting influences, are more worn into rounded heights, exposed crags, slopes, and terraces, which confer on the landscape a beauty and diversity peculiarly their own. Their soils being dry and genial, the trap hills of a country are generally possessed of great amenity and fertility, and constitute, perhaps, the most valuable agricultural portions of the district in which they occur.

3d. The *Granitic*, or oldest series of igneous rocks, consists of granites, syenites, porphyries, serpentines, and the like, which, from their more ancient and deep-seated relations, are generally hard and crystalline in texture and massive in structure. They constitute the nucleus or backbone, as it were, of all the higher and older mountain-chains—elevating the metamorphic schists into splintery peaks and abrupt ridges, or presenting of themselves broad massive shoulders of cold sterile moorland and unprofitable heath.

Connection between Geology and Physical Geography.

33. Understanding the nature of the preceding subdivisions, the student will be able to attach some intelligible idea to such phrases as the river "cutting its way through secondary strata;" "lying in an irregular tertiary basin;" "crossing a plateau of triassic sandstones;" "a cold retentive soil derived from the subjacent carboniferous rocks;" "intersected by a low range of trap hills, whose grassy slopes and terraces;" "bounded by sterile granitic ridges, whose snow-clad summits;" and hundreds of others that are of continual occurrence in geographical descriptions. He will still more fully perceive the intimate connection of geology with his own immediate science when he reflects that many of the soils which give character and colouring to vegetable growth are derived directly from the disintegration of the subjacent rocks, and are further affected in their fertility by the porous or retentive nature of the beds on which they rest. The

soil derived from the Chalk, for instance, is light and absorbent—hence the short sweet herbage of the "downs" of the south of England; that derived from the marls of the Trias is stiff, retentive, and less fitted for tillage than for pasture; the disintegration of trap rocks, rich in soda, potash, and lime, yields a fertile genial soil, which their structural fissures ever keep dry and pulverulent; while the scanty disintegration of an impervious granite is poor, cold, and barren. We have seen, moreover, that every geological formation is less or more characterised by its own special features. The soft rounded outlines of a chalk range is altogether distinct from the slopes, terraces, and conical heights of secondary trap hills; while these, on the other hand, are widely different, both in outline and in vegetable covering, from broad-shouldered mountains of granite, or the splintery peaks of metamorphic strata. In fine, these formations and rock-groups constitute the framework on which the geographical features are moulded; and their inherent characters, as subject to external and internal change, have produced, and are ever producing, new variety of superficial aspect. Every hill that volcanic energy raises above the general surface, every inequality produced by earthquake convulsion, every glen eroded by river-action, every plain formed by the deposition of alluvial silt, and every inch that one region is elevated above the ocean, or that another may subside beneath it, disturbs the existing geographical equilibrium, confers new features on the landscape, and modifies the habitats of vegetable and animal existences. Geology and geography are inseparably connected; and thus it is that some acquaintance with the nature and sequence of the rock-formations that constitute the solid crust, and with the causes that produce them, becomes so indispensable to the student of physical geography.

NOTE, RECAPITULATORY AND EXPLANATORY.

In the preceding chapter we have directed attention to the rocky structure of the globe as that which gives colour and character to all external phenomena, and is therefore of paramount importance to the student of physical geography. We have spoken of the "crust" composed of materials that can be seen and investigated as distinct from the "interior," of which nothing can be known by direct observation. This crust, composed of stratified and unstratified, or of water-formed and fire-formed rocks, is held in habitable equilibrium between the disintegrating forces of water from without, and the reconstructing forces of fire from within. To these two opposing powers are chiefly owing the continuous geological modifications of the earth's crust —each modification representing a period during which certain rocks were formed, and the remains of plants and animals that then lived entombed in them in greater or less perfection. These formations being arranged by the geologist in chronological sequence, and each varying in mineral character, and consequently conferring on the landscape different aspects, it is of importance in physical geography to know the order of this arrangement, and the nature of these distinctions. These *formations*, we stated, had been arranged into certain *systems*, and these systems again grouped into certain *periods*, according to the leading features of their fossils, thus :—

1. Post-Tertiary. 2. Tertiary.	CAINOZOIC.
3. Cretaceous. 4. Oolitic. 5. Triassic.	MESOZOIC.
6. Permian. 7. Carboniferous. 8. Devonian. 9. Silurian.	PALÆOZOIC.
10. Metamorphic. ...	HYPOZOIC.

As with the stratified so with the unstratified—their arrangement into *Volcanic*, *Trappean*, and *Granitic*, expressing the relative antiquities and nature of the great igneous groups that give character and individuality to the hills and mountain-ranges of the globe. So far, then, as diversity of surface, fertility of soil, character of landscape, and similar peculiarities, are concerned, the connection between physical geography and geology is intimate and inseparable; and hence the necessity that the student of the one should be less or more acquainted with the leading facts of the other. It by no means follows, however, that the student of geography should be deeply read in the theoretical problems of geology. An acquaintance with its general principles, and the causes that are incessantly productive of new modifications of the earth's crust, the leading formations that compose that crust, the nature of their rocks, and the character which these impart to the soil and landscape, is all, or nearly all, that he requires; and this information he can readily obtain from such manuals of the science as the Author's 'Introductory and Advanced Text-Books,' or Sir Charles Lyell's 'Principles' and 'Manual,' should he wish to extend his information beyond the outline sketched in the foregoing chapter.

IV.

DISTRIBUTION OF LAND AND WATER.

Their Relative Positions and Areas.

34. Having noticed the general conditions of the earth as a member of the solar system, and having also adverted to the structure of its own rocky crust as the groundwork of all geographical diversity, we now proceed to consider the more intimate relations of its surface, as composed of Land and Water. When we speak of the earth's surface as composed of land and water, we mean that all the more elevated portions of the crust stand out as dry land, while the lower and more depressed are covered by the waters of the ocean. Geologically speaking, the relations of land and water are continually, though slowly, undergoing change and modification; geographically speaking, and within the limits of such mutation, what are the respective areas of land and water, their positions on the earth's surface, their actions and reactions on each other, in consequence of their different extents, positions, capacities for heat, &c., and what the influence of these reactions on currents, winds, rains, and all those kindred phenomena that constitute climatic diversity? The present distribution of land and water tends to the production of certain physical and vital results, and the explication of these results forms the sum and substance of our science; but no portion of the present distribution could be altered either in its position, extent, or configuration, without being accompanied by a modification of these results, so intimately is the one element bound up with the other in the production of a definite and harmonious whole.

35. As formerly stated, the superficial area of the globe has been computed at 197,000,000 square miles. Of this amount about 51,500,000 consists of dry land, and about 145,500,000 of water; or reckoning the whole surface of the globe as equal to 1000 parts, 262 of these parts will consist of land and 738 of water. The

proportion of land to that of water is therefore nearly as *one* to *three;* or, expressing it fractionally, while *one-fourth* of the earth's surface is composed of dry land, the other *three-fourths* are covered by the waters of the ocean. Considered in hemispheres, northern and southern, the proportions of land and water are nearly as follows:—

Northern Hemisphere,	Land,	38,000,000	square miles.
Do. do.	Water,	60,500,000	,,
Southern Hemisphere,	Land,	13,500,000	,,
Do. do.	Water,	85,000,000	,,

There is thus about three times as much land in the northern as there is in the southern hemisphere; and if we make the estimate in eastern and western hemispheres (20° W. long. to 160° E. long.), there are about 37 millions square miles in the former, while there are only 14½ millions in the latter. As to the distribution of land and water in the different zones, it may be stated, in very general terms, that the land forms about *one-third* of the north frigid zone; *one-half* of the north temperate zone; *one-half* of the torrid zone; *one-tenth* of the south temperate zone—the amount in the south frigid zone being at present unknown. The *mean elevation* above the sea-level of all the land on the globe—islands as well as continents, mountains as well as plains—is estimated by Humboldt at somewhat less than 1000 feet. The *mean depth* of the ocean is calculated by Laplace, from the tides and other phenomena, to be at least 21,000 feet. "Hence," says Sir H. Holland, "allowing full margin for errors, the entire submergence of the land might take place, leaving the solid mass of the earth everywhere deeply covered with waters,—an elliptical globe of ocean, moving still under the influence of those sublime laws which had before guided its path through surrounding space."

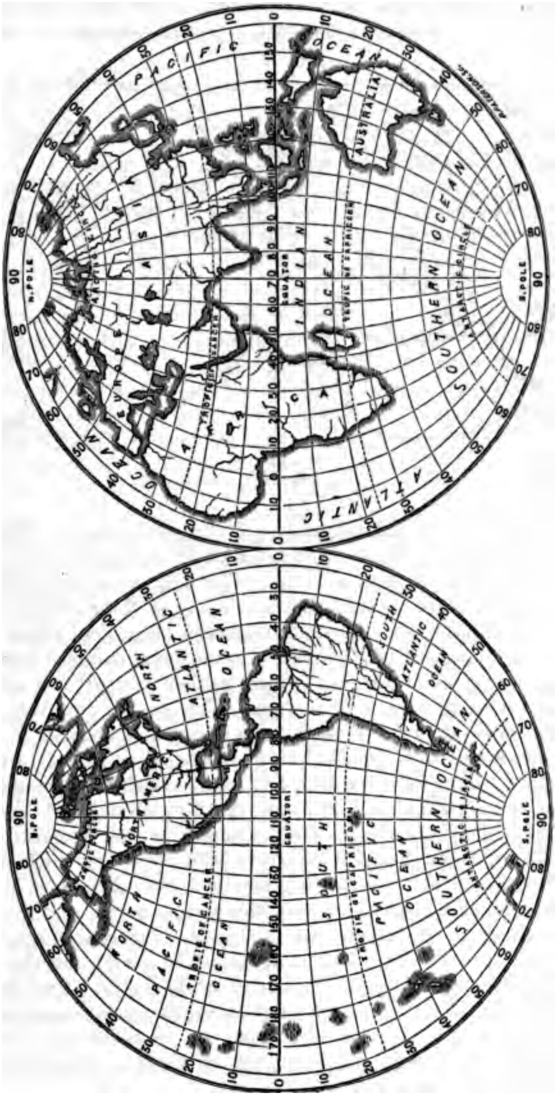
36. The boundaries of this terraqueous arrangement (Lat. *terra*, land; *aqua*, water) are extremely irregular. Here the land spreads out in broad unbroken masses, there the waters stretch away in vast continuous expanses; here the land rises up in mere specks and fragments, there the water inserts itself among them in areas equally limited and irregular. Here the land juts boldly out into the ocean, there the ocean runs sharply into the land; here the land trends uninterruptedly for leagues, there the ocean embays itself with gentle curves into the bosom of the land. Although this distribution seems to obey no regular order, and has been continually changing throughout all geological time, yet we may rest assured —and not the less assured because we are unable to discover it— that there is a law governing the insensibly varying relations of

sea and land, a power protecting the barriers of the one, and defining the "hither shalt thou come, but no farther," of the other. This boundary between the land and water is known as the *shore-line* or *coast-line*—the former having more especial reference to the margin washed by the waves, the latter to the terrestrial verge that opposes the ocean. The space alternately covered and laid bare by the tides is termed the *beach* or *strand;* and the fringe of land bordering on, and more or less influenced by, its proximity to the sea, is spoken of as the *seaboard* of a country or continent. This sea-belt is generally marked by the peculiarity of its plants and animals, as well as by the character of its inhabitants—these differing in many points from those of the interior or inland districts. In like manner, on the configuration of the shore-line depends much that relates to the climate as well as to the industry and commerce of a country. A regular and unbroken coast is generally an exposed and ungenial one, and one unfavourable to maritime enterprise; while one indented with gulfs and creeks and bays has more of genial diversity, and is better fitted for the purposes of navigation and commerce. As a general rule, the greater the number of miles of coast-line in proportion to the size of a country, the more valuable is that country for the requirements of industry and enterprise; and one has only to glance at the shore-lines of Europe, as compared with those of Africa or South America, to be convinced of this reality. The actions and reactions of the physical world are not more marked and certain than the influence of the physical on the intellectual and industrial; and but for the establishment of such deductions, geography would be shorn of half its interest and instruction.

37. A glance at the Map of the World will show that the land-masses are situated chiefly in the northern hemisphere—there being about three times as much land in the northern as there is in the southern hemisphere. And if we look at the distribution of this land as regards the zones of temperature, we will find that the greatest proportion is situated in the north temperate zone, or in that which contains all the better portions of Europe, Asia, and North America; while only comparatively narrow or isolated tracts are cut directly by the equator or central torrid line. Another glance at the map will show that while the land lies in broad unbroken masses towards the north, it stretches towards the south in curious gradually-tapering projections. Again, if we suppose the globe to be divided into hemispheres by the plane of the horizon of London (the dividing line being 90° all round from London), we will find that nearly all the land lies in the one hemisphere, while the other is almost wholly occupied by the

THE WORLD.

Western Hemisphere. Eastern Hemisphere.



waters of the ocean. The former (see illustration) is spoken of by geographers as the ***Continental*** or ***Land hemisphere***, while the

Land and Water Hemispheres.

other is termed the ***Oceanic*** or ***Water hemisphere***. These and other noticeable facts connected with the arrangement of sea and land have been often adverted to by writers on geography; and though it must be confessed that many of their comparisons are more curious than suggestive, there can be no doubt that the present arrangement is the result of some great cosmical law—a law concerning the nature of which neither geology nor geography can give any certain indication. This much, however, geology has shown, that the present terraqueous arrangement is not the arrangement that obtained in former ages, and that continents existed where seas now roll, and seas extended where continents are now established. We can readily account for the minor modifications of coast-lines—why some portions, composed of hard enduring rocks, should stand out in bold projections; while others, consisting of soft and wasting material, should be worn into bays and irregular recesses; but of the greater forces that slowly upheave some regions and as gradually submerge others, we are altogether ignorant. But while we fail to account for the present distribution of sea and land, and while we find that it is continually undergoing modifications under the operation of geological forces, we know that these changes are so silent and gradual as scarcely for ages to interfere with our ideas of geographical permanence and stability.

Their Subdivisions, Natural and Technical.

38. Admitting this condition of the terraqueous surface, it will be seen, on further reference to the Map, that the land is broken up into two main masses—that of the Eastern hemisphere, embracing Europe, Asia, and Africa, and described, from its being the only portion known to the ancients, as the *Old World*—and that of the Western hemisphere, including North and South America, and known (from its comparatively recent discovery by Columbus in 1492) as the *New World.* Properly speaking, there are only two great continuous land-masses or *continents* (Lat. *con* and *tenens*, holding together)—that of the Old World and that of the New; but geographers usually speak of six continents or principal sections, —viz., those of *Europe, Asia, Africa, North America, South America,* and *Australia.* Australia and its contiguous islands, together with those of the Southern Ocean, are frequently grouped as the sixth great division, under the title of *Oceania;* while others, drawing more restricted lines, speak of Australia and New Zealand as *Australasia*, and of the many islands of the Pacific proper as *Polynesia.** The areas of the respective continents, or *quarters*, as they are sometimes termed (though the "four quarters" of our forefathers embraced only Europe, Asia, Africa, and America), have been computed, with their respective islands, as follows:—

Old World, or Eastern Continent, .		31,250,000	square miles.
Europe, . .	3,725,000		,,
Asia, . .	16,165,000		,,
Africa, . .	11,360,000		,,
New World, or Western Continent, .		14,900,000	,,
North America, .	8,080,000		,,
South America, .	6,820,000		,,
Oceania, or Maritime World, . .		4,200,000	,,

39. The islands included in the above estimate are more or less closely connected with the continents to which they belong, though in truth the continents themselves are merely islands on a much

* The subdivisions Australasia or Southern Asia (*australis*, southern) and Polynesia, or many islands (*polys*, many; *nesos*, island), are sufficient for our present purpose; but the student may as well understand that many geographers and ethnographers speak of the East Indian Archipelago as *Malaysia;* of Australia, Papua, New Zealand, and the minor contiguous islands as *Australasia* or *Melanesia* (*melas*, black), in reference to the colour of their aboriginal population; of the numerous small Pacific islands north of the equator and east of Malaysia as *Micronesia* (*micros*, small); and of the many groups lying south of the equator and east of Australasia as *Polynesia.*

larger scale. In the disposition of the islands some curious coincidences have been noticed by German geographers, but these resemblances are in many instances more fanciful than real, and have no discoverable bearing either on the problems of geology or geography. Many of the larger islands—as Iceland, Spitzbergen, Novaia Zemlia, Madagascar, and the like—are solitary and independent; others again—as Tierra del Fuego, Sicily, Ceylon, Tasmania, &c.—are curiously connected with the extremity of some peninsula and continent, to which they form, as it were, mere outliers; while, in a majority of cases, the islands proper are found in clusters or *Archipelagos* (a term originally applied to Isles of Greece), such as the West India Islands, the Isles of Greece, the East India Islands, the Japan Isles, the Sandwich Islands, and many other groups that must at once present themselves on the most cursory inspection of the Map of the World. This disposition is no doubt in intimate connection with geological centres of uprise or depression—uprise into new continental areas, or depression into new seas; but the consideration of such oscillations in the earth's crust belongs more appropriately to Geology than to Physical Geography.

40. In describing the features and peculiarities of the Land, geographers make use of the following designations, which, though familiar in everyday language, may here, for the sake of method, be briefly recapitulated. Thus, a *continent*, as already indicated, is any extensive region uninterrupted or unbroken by seas; an *island*, any smaller portion surrounded by water; a *peninsula* (Lat. *pene*, almost; *insula*, island), a portion nearly surrounded by water; an *isthmus* (Gr.), the narrow neck that connects two adjacent masses of land, or a peninsula with the mainland; and a *cape*, *promontory*, *headland*, or *ness*, a point of land jutting out into the water. Besides these terms, which refer to the contour or disposition of the land as connected with water, there are others which relate to surface configuration or vertical relief. Thus, extensive flats are known as *plains*, *steppes*, *prairies*, *pampas*, and the like; smaller flats as *valleys*, *dales*, *straths*, *carses*, &c.; lands elevated more or less abruptly above the general surface are spoken of as rising into *hills*, or still higher into *mountains;* hills and mountains may stand less or more apart from each other and be *isolated*, may occur in *groups* as if connected with a common centre, or they may stretch away in determinate courses known as *chains* and *ranges;* while level elevated tracts are spoken of as *table-lands* and *plateaux*.

41. Though encircling the globe on every side, and in all its parts most intimately connected with one great ocean, the Water is still

divisible into certain areas that are more or less defined by the intervention of the land. Thus, on the west of the Old World, and between it and the New World, extends one main division known as the *Atlantic* (so called by the ancients from its washing the western base of Mount Atlas in Africa); on the west of the New World, and between it and the Old, expands another natural division known as the *Pacific* (from its comparative freedom from storms); while between Australia and its contiguous islands on the east and Africa on the west, lies the *Indian Ocean*. It is usual, however, to speak of *five* great oceans—viz., the *Atlantic*, *Pacific*, *Indian*, *Arctic*, and *Antarctic*—the two latter being respectively within the arctic and antarctic circles. In geographical descriptions it is also useful to employ the terms "North and South Atlantic," and "North and South Pacific," and to speak of the expanse that stretches away in unbroken vastness between the Indian Ocean and the south pole as the "Great Southern Ocean." The areas of these respective expanses are usually estimated as follows :—

Pacific Ocean, . . .	50,000,000	square miles.
Atlantic Ocean, . . .	25,000,000	,,
Indian Ocean, . . .	17,000,000	,,
Arctic Ocean, . . .	?	,,
Antarctic Ocean, . .	?	,,

Being ignorant of the amount of land that lies within the arctic and antarctic circles, and also of the exact extent of many islands both in the northern and southern oceans, the above must be taken as approximations merely; and, further, as amounts that do not embrace the areas of minor and *inland seas*—such as the North, Baltic, Mediterranean, Red, Black, Caspian, &c.—which occupy considerable spaces on the surface of the globe, and which exercise, moreover, a much greater influence on its climate, produce, population and industry, than their mere surface spaces would imply.

42. In treating of the waters of the globe, though there is, strictly speaking, only one great ocean, the term *ocean* is applied to the large uninterrupted expanses above defined; smaller areas are known as *seas;* gradual bendings of the water into the land as *bays;* deeper indentations as *gulfs;* minor and sudden indentations as *creeks, inlets, arms*, &c.; the narrow belts or openings connecting two adjacent seas as *straits*, or *channels;* and where the sea stretches inland to receive the waters of a river, such an expanse is known as a *frith* or *estuary*. Besides these general terms, there are others of a more local and restricted character, as the *fiords* or rocky inlets of Norway—the *lochs*, or lake-like sea-arms of Scotland—the *lagoons*, or shallow intercepted sheets that occur along

the shores of the Adriatic and other seas; but these will be best described under the respective areas to which they belong. Again, referring to the depth of the ocean, whose bed seems to be as irregular and varied as the surface of the dry land, geographers speak of *deeps* and *pits;* of *shoals* and *banks;* of sounds that may be readily reached by the sounding-line; of *roads* and *roadsteads* for anchorage; of *harbours* or landlocked inlets for shelter; and similar terms, whose meanings are so obvious as to require no special definition.

[Simple and obvious as most of these geographical terms may appear, each has still its own peculiar shade of meaning, and with this the student would do well to render himself early familiar. Where not explained in the text, definitions will be found in the Glossary, which should be regularly consulted as the term or technicality occurs. There is nothing so essential in geographical description as clearness and precision, and this can only be obtained by employing for the object described the term by which it is known, and this in such a way that it cannot be confounded with any other object, or mistaken for something else. Precise writing need not be dry reading; on the contrary, it is loose description that soonest fatigues, and leaves, in the long-run, the least satisfactory impression.]

43. Besides the great oceans and inland seas above alluded to, and which all consist of salt water, there are other considerable volumes that belong more especially to the land, and which consist mainly of fresh water, comparatively few being brackish or saline. These are the *springs* issuing from the earth's crust, and more or less impregnated with the mineral substances through which they have percolated; the *streams,* or runnels of water formed by the union of several springs; the *rivers,* formed by the union of streams, and often traversing whole continents with gradually increasing volumes; and the *lakes,* which occupy depressions in the land, and most frequently lie along the courses of rivers, though occasionally occurring isolated and apparently fed by springs, or, if receiving the waters of a river, have no river of discharge, but give off their surplus water by evaporation. The amount of surface occupied by these inland waters it is impossible to estimate with anything like accuracy; and this difficulty is greatly increased by the fact that, in countries subject to periodical rains, many tracts which become lakes and rivers during the wet season, are mere swamps and dry shingly channels when the period of drought returns. The main volumes of fresh water, as will be seen when we come to treat of the "River-systems," are the North American lakes, the lakes of Northern Europe and Central Asia, and the greater and more permanent rivers—as the St Lawrence, Mackenzie, and Mississippi in North America; the Amazon, Orinocco, and La Plata in South America; the Nile and Niger in Africa; the Ganges, Indus, Yang-tse-kiang, Lena, Yenesei, and

Obi in Asia; and the Volga and Danube in Europe. Springs, streams, rivers, lakes, and seas thus constitute what may be termed the geographical phases of water, or, in other words, its position and disposition on the earth's surface. Water, however, is circling everywhere, and is everywhere present, either in its aëriform, liquid, or solid condition. Floating in the air that surrounds us, circulating in the tissues of plants and animals, embodied in the substance of the hardest rocks, coursing over the earth's surface, or percolating deep in the solid crust, it is the great vital fluid of nature, by which the whole is permeated, combined, dissolved, reconstructed, and vivified in endless revolution and progress.

Their Mutual Actions and Reactions.

44. Such is the relative distribution, and such the general features, of the land and water that form the surface of the terraqueous globe. Whatever may have been their distribution in former ages as revealed by Geology, one thing is obvious, that in the present era they are, within certain limits of change, mutually adapted and harmoniously adjusted. The land absorbs and radiates the sun's heat more readily than the water; and thus, while parched and thirsty in summer, it is refreshed and vivified by the moisture evaporated from the more extensive ocean; while in winter its tendency to grow colder is modified by the heat given off by the ocean, whose slower radiation renders it, as it were, a great storehouse of latent heat for the exigencies of the land. Besides this interchange of heat and moisture, there is also the interchange of aërial currents and winds, caused by the unequal capacity of the two great surfaces for heat; and thus, as will be more fully explained hereafter, the whole machinery of climate—hot winds, cold winds, vapours, rains, and the like—is set agoing by the primary differences existing between land and water. As at present distributed, a certain amount of moisture is evaporated from the ocean and carried to the land, a certain amount of heat is interchanged—certain winds blow at certain seasons, certain tides rise and fall, and certain currents flow in the performance of certain functions; but all this would be changed by the slightest alteration either in the relative areas, in the relative configurations, or in the relative positions of land and water. In their present areas, configurations, and dispositions, the two elements are harmoniously adapted for the production of certain results, geological, climatological, and vital; and the student must readily perceive how the force of tides and waves and currents would be

altered, the climate of regions changed, and their plants and animals affected by the slightest disturbance in the existing terraqueous arrangements. Let North and South America be severed by the disappearance of Panama—let the bed of the Atlantic be upraised so as to deflect the Gulf Stream on the coasts of Greenland instead of those of Europe—let the central plain of Europe be submerged so as to be occupied by another Mediterranean,—let these, or any similar set of changes be effected on the present arrangement of the continents and oceans, and a whole host of new secondary influences would be set in motion, altering the climates and modifying the kind and character of the plants and animals that people these regions. So intimately, in fact, does the conditions of the one element depend upon those of the other, and plants and animals upon both, that not a league of land could be converted into sea, or a league of sea-bed upheaved into dry land —the land raised a foot higher or the sea become a foot deeper— without a corresponding change being effected on the whole economy, physical and vital, of our planet.

From Nature's chain whatever link you strike,
Tenth or ten-thousandth, breaks the chain alike.

NOTE, RECAPITULATORY AND EXPLANATORY.

The facts detailed in the preceding chapter are so simple and obvious, that they require little recapitulation or further explanation. The surface of the globe, or that which comes in contact with the atmosphere, is partly occupied by land and partly by water —the former constituting more than a fourth, and the latter about three-fourths of the entire area. On a cursory inspection of the map of the world, the land will be seen to resolve itself into two main masses—the Eastern hemisphere or Old World, and the Western hemisphere or New World; and these by geographers are usually further subdivided into the so-called "quarters" or continents of Europe, Asia, and Africa in the former; North and South America in the latter; together with a south or insular division, embracing Australia, &c., under the name of Oceania. Of these continents the greater portion lies in the northern hemisphere, the broader masses spreading out towards the north, and gradually narrowing towards the south in the cape-like projections of South America, Africa, Hindostan, and the Malayan Peninsula. The

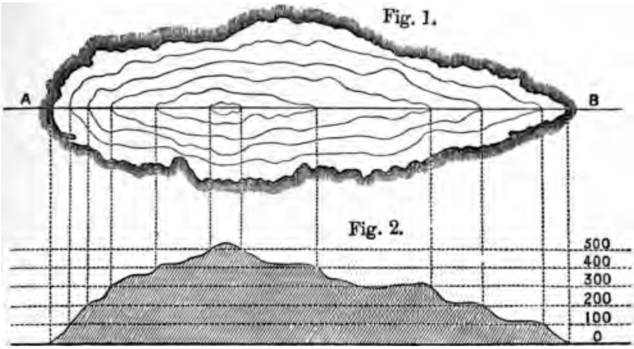


Fig. 1.

Fig. 2.

dation to which they have been subjected. It is in this manner that hills composed of hard basalts and greenstones, alternating with soft tufas or stratified rocks, assume *terraciform* declivities; that extinct volcanic hills, like those of Auvergne, put on a *crateriform* aspect; that those largely composed of hard massive strata—as limestone, conglomerates, and sandstones—present a *tabular* appearance; and that mountains capped and flanked by crystalline schists are *serrated* with peaks and pinnacles.]

57. With these explanations, the principal Mountain-Systems, whose direction and extent will be best seen on reference to the Atlas, may be here enumerated—the student remembering that there is much in this arrangement that is arbitrary, or, at all events, not sufficiently established by actual observation. Thus, in Europe, geographers usually distinguish the *British system*, comprising the Grampians, Cheviot, Cumbrian, Cambrian, and Hibernian ranges; the *Iberian* or Spanish, embracing the Pyrenees, the Cantabrian Mountains, the Sierra Morena, Sierra Nevada, and the sierras of the central table-land; the *Sardo-Corsican*, consisting of the mountainous range of Sardinia and Corsica; the *Alpine*, including the Alps proper, Apennines, Carpathians, Balkan, and Hellenic ranges; the *Scandinavian*, or mountain plateaux of Norway and Sweden; the *Sarmatian*, or central high-ground of Russia; the *Uralian*, and *Caucasian*. In Asia we have the *Western system*, comprising the Taurus, Anti-Taurus, Lebanon, Armenian, and Elburz ranges; the *South-eastern system*, embracing the Hindoo Koosh, the Himalaya, and the mountains of Birmah, Siam, and Cochin-China; the *Eastern system*, comprising the Kuen-lun, the Pe-ling, Yun-ling, Kihan-shan, In-shan, and other Chinese ranges; and the *North-eastern system*, extending from the Bolor Tagh in the centre of the continent to Behring Strait, and comprehending the Thian-shan, the Altai, Yablonoi, and Stannovoi ranges. In Africa may be enumerated the *Atlas system;* the *Guinea system*, embracing the Kong and Cameroon Mountains; and, so far as is known, the *Eastern system*, comprehending such as the Quotlamba, Lupata, and other contiguous ranges. In North America, the *Pacific system*, embracing the great range of the Mexican Cordilleras and the Rocky Mountains, on the west of the continent; and the *Atlantic* or *Appalachian system* (Alleghanies, &c.) on the east. In South America there is the giant system of the *Andes* in the west, the *Brazilian system* in the east, and the system of *Parimè* between the rivers Amazon and Orinocco in the north. Of Australia and its mountain-chains we know too little as yet to enable us to arrange them into groups or systems, though one main ridge, extending along the eastern coast from Torres Strait on the north to the extreme point of Tasmania on the south, would seem to indicate a sameness and continu-

ity of geological upheaval. Besides the above, other minor systems have been named; but enough has been indicated to lead the student to the appreciation of the fact that the principal mountain-chains may be arranged in groups or systems that have arisen apparently from the same set of geological causes acting more or less continuously along the line or direction of their elevation.

[Touching the general distribution of mountains, it has been aptly remarked by Sir John Herschel that, "In the New World we find a continuity of a vast and extremely precipitous line of very elevated mountains, running from the Arctic Ocean almost to the extremity of Patagonia (a distance of 8280 statute miles), skirting along the western coast of that immense continent, closely following all its flexures in the southern half, and in the northern opening out somewhat more, it is true, but still preserving the same general character of a lofty, mountainous, western border to a vast expanse of eastern lowlands; and, throughout the whole of this border, we perceive a most distinct and unmistakable tendency to a system of double or triple ridges, nearly or exactly parallel, not here and there for short distances, but extending for hundreds of miles in succession, and resumed again and again when interrupted. In the Old World, on the other hand, we find no single, well-defined, continuous chain running throughout, much less following the coast-line, but a broad belt of mountainous country traversing the whole mass of land in a general direction, and carried through the heart of the continents, from the extremity of Europe and North Africa across to the western shores of the Pacific. In the European portion of this system, linear prolongation, except in the Pyrenees, is very far from distinctly indicated. On the contrary, divarication and embranchment are there the dominant features, as they are especially so in the north-western region of Asia; and it requires some determination in tracing connections to follow out a leading line through the Pyrenees, the higher Alps, the Caucasus, and the mountains of Elbrouz, through the Hindu Koh, up to the great system of Asiatic mountains which enclose the plateau of Thibet. Neither is the principle of parallel association carried out with anything like the same precision and sequence in the old as in the new continent. Along the Caucasian and Elbrouz range, and as far as the termination of the Hindu Koh, this principle is pretty clearly maintained; but from the point in Little Thibet where this last-mentioned system forks out into the two great chains of the Himalaya and Kuen Lun which enclose the table-land of Thibet proper, a greater degree of confusion and interlacement prevails, and beyond the termination of these ranges in Assam and on the Chinese frontier, the mountain-system of China and south-western Asia spreads out like an immense fan, in some of whose ranges a high degree of parallelism is preserved among contiguous members, while in others the branching character prevails quite as conspicuously."]

58. As mountain-systems exercise very decided influences on the natural history of the globe, and as they generally appear in ranges consisting either of one central chain with branches or spurs running off at right angles, or of several chains running less or more parallel to each other, various theories have been advanced to account for their upheaval, their parallelism, and their geographical connections. Thus, as their central masses generally consist of igneous rocks (compare Geological Map of Europe with Map of Mountain-systems), which have been protruded from below, and as this pro-

truding force must have acted along the line of least resistance in the crust, the question arises, What is the determining cause of these directions? According to Elie de Beaumont, the French geologist, every system of mountains occupies a portion of a great circle of the globe—a cleft or fissure being more easily made in that direction than in any other; and he shows that the mountain-chains of the same age are parallel to one another even when in opposite hemispheres. Professor Hopkins of Cambridge, treating the subject from a purely mathematical point of view, has also shown that when the upheaving force acts on a single point, the lines of upheaval must radiate from that point; hence lofty central mountains with diverging spurs. He further shows that when the expansive force acts uniformly over a wide area, the lines of greatest tension or upheaval must be in the direction either of the length or of the breadth of the area, and that, if the crust yields in more places than one, the fissures would necessarily be parallel. Of course this uniformity of system has been considerably obscured, if not modified, by subsequent geological changes; and it must also be remembered that, whatever may give the initial direction to a mountain-range, its subsequent increase is ever more a matter of *accumulation* than of *upheaval*.

European Systems.

59. Accepting such generalisations as initiatory steps towards the explanation of one of the most important problems connected with the history of our planet, we may now advert to the character of the *mountain chains* or *ranges* of which the preceding systems are respectively composed. Under the *British system* are embraced the Northern or Ross-shire range, the Grampians, the Cheviots, the Cumbrian or Cumberland mountains, the Cambrian or Welsh, the Devonian, and the Hibernian or Irish, all having less or more a south-west and north-east strike, and all belonging to the eastern or primary geological periods. Their geological structure—huge granitic bosses flanked and capped by the crystalline schists—confers on them considerable boldness and diversity of scenery, though their minor elevation prevents that massive grandeur and ruggedness so often displayed by loftier ranges. None of them rise to the height of perpetual congelation (about 5000 feet for the centre of the British Islands); but in an insular and northern position such as that they occupy, their cold, heath-clad, inhospitable summits exercise a decided influence alike on climate, scenery, and natural productions. Arranging them in

tabular order, with their culminating heights or points of highest elevation, they appear as follows:—

Northern or Ross-shire range, Ben Attow, .	4000 feet.
Grampians, Ben Nevis, . . .	4368 ,,
Cheviots, ...	2741 ,,
Pennine chain, ...	2911 ,,
Cumbrian or Cumberland range, Scaw Fell, .	3166 ,,
Cambrian or Welsh mountains, Snowdon, .	3571 ,,
Devonian range, ...	2077 ,,
Hibernian mountains, M'Gillicuddy's Reeks, .	3410 ,,

60. The *Iberian* or *Hesperian system* embraces the Pyrenees, Cantabrian Mountains, Mountains of Toledo, Sierra Morena, Sierra Nevada, and other associated elevations that give character to the rocky table-land and peninsula of Spain. Less ancient than the British system, but loftier in their altitude and more extensive in their ranges, they exercise a still more decided influence on the external condition of their region. Ranging chiefly in an east and west direction, and upheaving rocks of primary and secondary formation, rising, in many parts, above the line of perpetual snow (which ascends from 8000 feet in the Pyrenees to 11,000 feet in the Sierra Nevada), and being intersected by numerous deep defiles and narrow valleys, they create great diversity of scenery, climate, and production, and are of themselves the frequent storehouses of the minerals and metals. Arranged in tabular form, with their culminating points, they are as follows:—

Pyrenees, Maladetta, . . .	11,168 feet.
Cantabrian Mountains, S. Gredos, . .	10,552 ,,
Mountains of Toledo, S. Guadalupe, .	5,110 ,,
Sierra Morena, Aracena, . . .	5,550 ,,
Sierra Nevada, Mulhaçen, . . .	11,687 ,,

61. The *Sardo-Corsican system*, as its name implies, is confined to the islands of Sardinia and Corsica, and extends from Cape Jeulada in the former, to Cape Corso in the latter. It is a high, rugged, and irregular range, attaining its culminating point in Monte Rotondo, in Corsica, which rises to the height of 8767 feet—an elevation closely bordering on the line of perpetual snow, which in that latitude ascends to 9000 feet. In its geological bearings it is evidently connected with the Alpine development, and ought, properly speaking, to be regarded as a mere outlier of that gigantic system.

62. Under the *Alpine system* are usually comprehended the whole of those extensive and lofty mountains which, from Switzerland as a centre, ramify in ranges more or less persistent, and confer on southern Europe one of its most marked and peculiar

features. These ranges have many minor subdivisions, but for our present purpose it will be enough to arrange them into the Western and Eastern Alps, which, under several local names (the Maritime, Cottian, Graian, Pennine, Helvetian, Bernese, Phætian, Carnic, Noric, and other Alps) extend in a north-east direction from the shores of the Mediterranean to the table-land of Bohemia; the Gallo-Francian mountains, including the Jura, Vosges, and other contiguous French ranges; the Apennines, traversing the entire length of the Italian peninsula, and terminating in the still active volcano of Etna; the Slavo-Hellenic ranges, lying between the shores of the Adriatic and the plain of the Danube, and which stretch eastward into the Balkan chain on the one hand, and southward into the Pindus chain on the other; and, lastly, the long range of the Carpathians, Krapacks, or Hercynian Mountains, which rise between the plain of the Danube and the great plain of Europe, and mark the northern limits of the system. The component members of this grand Alpine system are of various geological ages, ranging from the granites and crystalline schists of the Western Alps, through the secondary limestones and altered shales of the Jura, down to the tertiary beds of the sub-Apennines and the recent lavas and scoriæ of Vesuvius and Etna. Connected with the older range of the Pyrenees on the west, and with the still active craters of Vesuvius, Etna, and the Lipari Islands on the east, the Alpine system may be said to have been on the increase from the earliest geologic times to the present moment—gaining accession after accession, and this even since the tertiary period, to much of the Auvergne, Apennine, and Hellenic ranges, and to the Alps themselves an additional altitude of not less, perhaps, than 4000 or 5000 feet. Being of different geological structures and altitudes, the different members of the system present great diversity of character and aspect. Rising in many places above the snow-line, which sinks from 9000 feet in the Alps to 6000 feet in the Carpathians, they are rugged with peak and precipice, glacier and narrow gorge, as in the Helvetian Alps; swelling and sloping in outline, as in the Apennines; crateriform and terraced, as in the hills of Auvergne; rocky and precipitous, as in the Balkan and Pindus ranges; or rich in minerals, as in the mountains of Transylvania. With the exception of the plains of Bavaria and Bohemia, which lie on the very outskirts of the system, there are no table-lands, in the proper sense of the term, connected with the development—the whole being a true typical mountain-series of ridge and valley, peak and pass, beetling precipice and rugged ravine. Subjoined are the component ranges of the system, with their culminations or points of highest elevation:—

Western Alps, Mount Pelvoux, . .	14,108 feet.
Eastern Alps, Mount Blanc, . .	15,744 ,,
Gallo-Francian, Mount Mollecon, . .	6,588 ,,
Apennines, Mount Etna, . . .	10,874 ,,
Slavic range, Mount Kom, . . .	9,000 ,,
Hellenic range, Olympus, . . .	9,749 ,,
Balkan range, Mount Athos, . .	9,628 ,,
Carpathians, Butschetje, . . .	7,528 ,,

63. The *Scandinavian system*, as the name implies, embraces the whole of the mountainous highland of Norway and Sweden, and extends in a north-eastern direction from the Naze to the North Cape, a distance of 1160 miles. It consists of a series of plateaux, or high open fields, rather than of a continuous mountain-ridge—these elevations narrowing from a breadth of 200 miles in the south to 60 or 40 in the north, and being distinguished as the Hardaangar or Langefeld in the south, the Dovrefeld in the middle, and the Kiolen Mountains in the north. Intersected by numerous ravines and gorges, the range presents a steep face and rugged coast-line of fiords and cliffs to the North Sea on the west, and a terraciform slope to the shores of the Baltic on the east. A great portion of the range rises above the limit of perpetual snow (which ascends from 2400 feet at the North Cape to 5000 feet in the Langefeld), but beneath this limit the mountain-sides are covered with straggling forests of birch and pine. Geologically speaking, the whole system is of primary origin—granitic, crystalline, and silurian rocks composing the mass, which is abundantly traversed by metalliferous veins of iron, copper, lead, zinc, and antimony. Though the general elevation of the irregular table-lands seldom exceeds 5000 feet, the culminating points rise to a considerable altitude; thus—

Langefeld, Skegstol-tend, ...	8670 feet.
Dovrefeld, Sneehatten, ...	7620 ,,
Kiolen, Sulitelma, ...	6200 ,,
,, North Cape, ...	1161 ,,

64. The *Sarmatian system* (from the ancient Sarmatia or Poland) is meant by geographers to embrace that extensive swell of country which stretches diagonally through Russia from the plain of Poland to the flanks of the Uralian Mountains, and which forms the great watershed of northern Europe, turning the waters of the Vistula, Duna, Dwina, and Petchora to the Baltic and White Seas; and those of the Volga, Don, and Dnieper to the Caspian and Black Seas. There are no mountains throughout its extent, the Valdai Hills attaining an elevation of only 1100 feet; and it is chiefly of geographical importance as a great and continuous watershed.

65. Under the *Uralian system* geographers embrace the well-known range of the Ural Mountains, which form the natural boundary between Europe and Asia, and the watershed between the extensive basins of the Volga and Obi. The range, being transverse to the usual strike of the Old World mountains, runs in a true meridional direction for a distance of more than 1600 miles, and consists of round-backed, plateau-shaped masses of very moderate elevation, generally not exceeding 2000 feet, and culminating in a few points only at upwards of 5000 feet. The range is a truly mono-lineal or mono-axial one, and consists of an axis of igneous rocks, flanked by crystalline schists and the older palæozoic formations, and is rich in the precious minerals and metals—gold, platinum, iridium, copper, and diamonds being among its geological treasures. Its culminating points are—Konjak-Ofski, 5397 feet, and Obdorsk, 5286 feet.

66. The *Caucasian system*, which forms another part of the boundary between Europe and Asia, extends in one immense chain of 750 miles from the Black Sea to the Caspian, and separates the basins of the Kuban and Terek on the north, from those of the Kur and Rioni on the south. The range is a massive and lofty one, full of glens and mountain-fastnesses, and rises in many places above the snow-line, which there attains to the altitude of 11,000 feet. The culminating point is Mount Elburz, near the centre of the chain, its height being 18,493 feet, or 2749 feet higher than Mount Blanc; and, being on the European side, is thus the highest point of the Continent. Several other points rise far above the snow-line, among which may be mentioned Kasbek, 16,532 feet, and Savalan, 15,750 feet.

Asiatic Systems.

67. Turning next to Asia, which is the main headquarters of mountains and mountain-chains in the Old World, as well as the region of highest elevation on the globe, we may begin with the *Western system*, under which is comprised those more or less associated ranges that lie between the Levant and Black Sea on the west, and the Indus on the east, and which give feature and character to the contiguous highlands of Asia Minor, Persia, Affghanistan, and Beloochistan. Among these may be noticed the Taurus and Anti-Taurus, whose hilly and irregular ranges encircle the table-land of Asiatic Turkey, and whose culminating point is Mount Argish, attaining an elevation of not less than 13,000 feet. A considerable portion of these ranges is above the

snow-line, and though the table-land they support is on the whole bleak and humid, their own slopes are often intersected by valleys of great beauty and fertility. Closely connected with them, topographically as well as geologically, is the Lebanon range, which, proceeding transversely from the Taurus, stretches southward along the Syrian coast to Mount Hermon, 10,000 feet high, and thence through Palestine to the peninsula of Sinai, where Horeb, 8593 feet, and Sinai, 7497 feet, terminate the chain. In the northern portion of the chain the loftier heights are covered with perpetual snow, while the lower slopes are wooded and fertile; but in the southern portion, the mountains, though lower, are abrupt, rocky, and arid. Also intimately associated with the Taurus and Anti-Taurus, and in fact but prolongations of the same ranges, are the mountains of Armenia, which trend eastward in the Elburz, and southward into the Zugros and hills of Kurdistan. They form a series of broad-shouldered mountains, with lofty intervening valleys, and culminate in the steep-sided, snow-covered cone of Ararat, 17,210 feet high. The Elburz range—a continuation, as it were, of the Armenian and Taurus mountains—skirts the southern shores of the Caspian, where it attains, in the slumbering volcano of Demavend, an altitude of 21,000 feet, and thence stretches eastward, with less defined elevation, into the high grounds of Tartary and the chain of the Hindoo Koosh. This last-mentioned range, the Hindoo Koosh or Hindoo Koh, separates Affghanistan and the Punjaub from Independent Tartary, and forms the watershed between the Amoo and the Indus. Its maximum elevation is about 20,000 feet, and, trending eastward in broad massive ridges into the Kuen-lun and Himalayas, it may be regarded as the commencement of the great central system of the Asiatic continent. Such are the principal members of the *Western mountain-system* of Asia, which are all intimately connected with the first plateau stage of that continent. In the main, they run in east and west directions, though sending out several southern spurs, as the Lebanon, Kurdistan, and Beloochistan hills. They are largely of secondary and tertiary age; and though intersected by minor valleys, they fade away rather into high arid table-lands than alternate with river-plains of corresponding dimensions—those of the Euphrates and Jordan being the only alluvial plains of any importance. The following are among the highest points of the system:—

Hindoo Koosh, summit, . . .	20,232 feet.
Elburz range, Demavend, . . .	21,500 ,,
Armenian mountains, Ararat, . .	17,210 ,,
Anti-Taurus, Argisch, . . .	13,197 ,,

Taurus, summit, ...	9,800 feet.
Lebanon, Jebel-el-Makmel, . . .	12,000 ,,
,, Hermon, ...	10,000 ,,

68. Closely connected with, and following the western, is the great *South-eastern system of Asia*, extending from the Knot of the Bolor Tagh to the extremities of Malay and Cambodia, and comprising not only the highest mountains in that continent, but the highest known elevation on the surface of the globe. Pre-eminent in the system stands the chain of the Himalaya ("abode of snow"), stretching in a somewhat south-easterly direction between the basin of the Ganges and the upper basin of the Brahmapootra, forming the northern and all but impassable boundary of India, and constituting the southern buttress of the great central table-land. The range extends about 1500 miles in length; varies from 150 to 350 miles in breadth; has a mean elevation, according to Humboldt, of 15,670 feet; and rises in many points (upwards of forty, it is said) to an altitude of 20,000 feet—the three highest peaks being Everest, Gahurishank, Chingopamari, or Deodunga, 29,002 feet; Kinchinjunga, 28,178 feet; and Dwhalagiri, 27,826 feet. The snow-line rises, according to position in the range, from 13,000 feet on the south side, to 16,000 feet on the north side, where the air is drier; and a large portion being thus perpetually covered with ice and snow, the Himalayas present every possible feature of mountain grandeur—peak and precipice, gorge and glacier, rugged ravine and headlong waterfall. Geologically speaking, the higher and central portions of the Himalaya, with a few volcanic exceptions, consist of granitic and metamorphic rocks; their flanks exhibit in many places palæozoic secondary strata; and at elevations of 3000 and 4000 feet along their bases—the Siwalik or sub-Himalayan hills—occur limestones and gravels replete with the remains of tertiary mammals. Indeed, the whole chain, as well as a large portion of the Asiatic continent, has been elevated many thousand feet since the tertiary epoch—tertiary fossils being found on the terraces, passes, and plateaux, at elevations of 6000, 10,000, and even 17,000 feet above the present sea-level. Abruptly separated from the Himalaya by the transverse valley of the lower Brahmapootra, but still holding less or more in the same axial direction, are the mountains of Assam, a congeries of great irregular heights, partaking of much of the Himalayan character, but as yet very partially known or explored. Beyond the mountains of Assam, but still in continuation of the system, lie the well-defined ranges of Burmah, Siam, and Cochin-China—all trending in a southerly direction, separated by low-lying river-valleys, and giving contour and character to the

Cambodian and Malayan peninsulas. Little is known of these peninsular mountain-ranges, or of their elevations; but, well-watered and approaching the equator, we know that to great elevations they are covered with impenetrable forest-growth. Outlying the system, but still connected with the same area, are the mountains which give figure and relief to the peninsula of Hindostan. These are the Vindhya chain, which forms, as it were, the northern barrier of the Deccan; the Western Ghauts, that guard it on the west; and the Eastern Ghauts, that support it on the east—the two latter chains converging into the loftier heights of the Nilgherri Hills in the south. The plateaux of the Deccan rise step by step southward from 1500 or 2000 feet in Nizam, to 4000 feet in Mysore; the Western Ghauts ascend from 3000 to 5700 feet; the Eastern from 3000 to 4000 feet; and the Nilgherries in many points from 6000 to 7000 feet—attaining their culmination in the peak of Dodabetta, 8760 feet high. Tabulating the south-eastern system, with its culminating points, we have,—

Himalaya, Everest, ...	29,002 feet.
,, Kinchinjunga, ...	28,178 ,,
,, Dwhalagiri, ...	27,826 ,,
,, Nandadevi, ...	25,749 ,,
Nilgheri, Dodabetta, ...	8,760 ,,
Western Ghauts, Tandiamole, . . .	5,781 ,,
,, Bonasson, . . .	7,000 ,,
Eastern Ghauts, ...	4,000 ,,

69. Starting from the same central ganglion of the Bolar Mountains and extending eastward to the Pacific, we have next the *Eastern system of Asia*—a series of vast and partially known ranges, associated with high desert table-lands in Tibet and upper Tartary, and alternating with alluvial plains in the eastern districts of China. The system commences with the chain of the Kuen-lun, rising between the valleys of the upper Indus and Brahmapootra on the south, and those of the Amoo and Yarkand on the north, and extending in an easterly direction for nearly 1200 miles, at an altitude of 15,000 to 18,000 feet. Lying as it does in the same line with the Elburz on the west, and prolonged into the Pe-ling on the east, the whole looks like one great range, and is, no doubt, geologically dependent on the same axial elevation. As the Himalaya formed the southern, so the Kuen-lun forms the northern wall of the plateau of Tibet, the loftiest inhabited region in the world, having a mean elevation of 15,000 feet above the sea, and rising from 12,000 feet in its western area to full 17,000 feet in the east. Holding eastward, as we have stated, into the main ridge of the Pe-ling Mountains, that rise between the

basins of the Yang-tse-Kiang and Hoang-Ho, the system at the same time diverges, fan-like, into the Yun-ling chain, between Tibet and China; the Nan-ling, between the basins of the Yang-tse-Kiang and Canton River; and the conjunct chains of the Ala-shan, In-shan, and Khingan, that trend in a north-easterly course, and form the southern wall of the great Mongolian desert. Altogether, the Eastern system is little known to geographers, either as regards the altitude of its mountain-chains, their physical features, their geological structure, or the minerals and metals they contain.

70. Commencing, in like manner, with the central knot of the Bolor, and stretching away in broad, more or less parallel, lines to Kamtchatka and Behring Strait, occurs the *Northern system of Asia*, flanked by the arid deserts of Tartary and Mongolia on the south, and descending by gradual stages to the great plain of Siberia on the north. The system embraces the Thian-shan or Celestial Mountains, ranging in an easterly direction for nearly 1400 miles, ascending in greater portion above the line of perpetual snow, but comparatively free from glaciers on account of the dryness of the air, and exhibiting throughout a number of volcanic cones, some of which, like Pe-shan and Ho-tscheou, are still active at elevations of more than 10,000 feet. In north-easterly continuation we have next the Altai Mountains, comprising several parallel ridges (the Tang-nu, Ulam-gom, and Dzungari), the Daurian, Yablonoi, and other little known ranges—all rising between Siberia and Mongolia, and separating the basin of the Amoor from those of the Yenesei and Lena. These closely associated ranges are said to have a mean elevation of from 5000 to 8000 feet; embrace several active and many extinct volcanoes; rise high in numerous points above the snow-line, which is there about 6000 feet; and culminate occasionally in peaks of 10,000 and 11,000 feet. Like other clustering ridges, the Altai and Daurian Mountains enclose a number of lakes, which find an outlet by narrow cross valleys, and terrace by terrace downwards to the larger rivers of Siberia. Still northward and eastward, but ramifying more irregularly, occur the Aldau, Stannovoi, and other chains that terminate in the volcanic system of Kamtchatka. These ranges are for the most part covered with snow (the snow-line sinking to 4500 and 4000 feet in Eastern Siberia), and contain numerous volcanic cones which, like Schiwelutch, 10,548 feet, and Klieutschewska, 15,955 feet, are still in active eruption. Indeed, the whole system is more or less volcanic—active cones, dormant craters, hot springs, gas-springs, and other kindred phenomena, marking the broad line of mountainous elevation that extends from Demavend on the Caspian to Klieutschewska in Kamtchatka.

African Systems.

71. Of the African continent, to which we next turn, our knowledge is yet too limited to enable us to do more than merely advert to some of the more prominent mountain-regions, as likely embracing within their limits the elements of separate and independent systems. Our knowledge of Africa, however, is every year becoming more precise, and in no feature is it more interesting than that which reveals an interior of mountain and plain, river and lake, instead of, as at one time supposed, an arid and monotonous desert. In the extreme north we have the *Atlas system*, between the Mediterranean seaboard and the Sahara, and extending from Tripoli on the east to the Atlantic on the west. Geologically, it is evidently connected with the systems of southern Europe, and consists of three or four parallel ranges, which ascend stage by stage from the basin of the Mediterranean, and increase in altitude from east to west—being about 2000 feet in Tripoli, 4500 in Tunis, 7700 in Algeria; while in Morocco, Mount Miltsin, or Atlas, ascends to 11,400 feet, and Jebel Tedla to 13,000 feet, or above the line of perpetual congelation. Several secondary spurs proceed from the main ranges—one northward, and terminating in Cape Spartel at the Straits of Gibraltar, and several others southward into the desert plateaux of the Sahara.

72. Next in importance is the *Abyssinian system*, connected with and forming the lofty table-land (Amhara) of Abyssinia and upper Ethiopia—the gathering ground of the Atbara and Blue Nile. This plateau, which is 8000 feet above the sea-level, is supported and traversed by several clustering ranges of great elevation, and in many points above the line of perpetual snow, which is there about 14,000 feet. The two most persistent chains, under the names of the Samen and Taranta, strike in a northerly direction between the upper forks of the Nile and the Red Sea, and, skirting the shores of the latter, are prolonged into the lower hills of Egypt, which at the Gulf of Suez connect themselves with Sinai and the mountains of Syria. The culminating points in the Samen or upper range are Ras Detschen, 15,986 feet; Buahat, 15,000 feet; Abba Jarrat, 14,707 feet; and Umbattai and Beyeda, each 12,000 feet. In the Taranta or lower range, the heights descend from 9000 to 6000 and 5000 feet towards the Red Sea and the plain of Egypt. The system consists largely of granites, syenites, porphyries, and crystalline schists, and exhibits, in the higher range, that bold and rugged character distinctive of these formations.

73. In Western Africa the mountains are by no means well known,

but under the *Guinea system* are usually embraced the Kong and Cameroon Mountains—the former rising between the Gulf of Guinea and the Niger, and generally averaging from 1200 to 3000 feet (Soracte, 1278, and Mount Ramel, 3200 feet); and the latter stretching eastward and unknown into the centre of the continent, and rising in many points to elevations of 4000, 6000, 9000, and even 13,000 feet. From the Cameroons, southward to Damara Land, the seaboard rises in terraces, backed by several ranges, of which very little is known; though the Campleda chain is said to attain an elevation of from 12,000 to 14,000 feet; the Mozamba, from 8000 to 10,000 feet; and the Omatako Berg, from 8000 to 9000 feet.

74. In Southern Africa the surface is occupied by a series of sandstone plateaux, resting on, and intersected by, granitic rocks, rather than characterised by a series of well-defined mountain-chains—these flats (*karoos*) rising step by step, from south to north, at elevations of 2000, 4000, and 6000 feet above the sea-level. The steps of this ascent consist of rocky walls and flat-topped mountains, ranging in an east and west direction, and intersected by narrow defiles (*kloofs*), which form the only means of passage from terrace to terrace; and these mountains (*bergs*) may, for the sake of reference, be denominated the *Cape system*. It consists, 1st, of the Zwellendam range, about 20 miles inland from the Cape coast, and stretching for nearly 200 miles in length, and attaining, in Table Mountain, an elevation of 3816 feet; 2d, the Zwarte or Black range, about 30 miles further north, and separated from the Zwellendam by the Kannaland Karoo; and, 3d, the northern chain, consisting of the Roggeveld, Nieuwveld, Winter Mountains, Sneeuwveld, Wittebergen, and other contiguous ranges, separated from the Zwarte hills by the great Karoo, and attaining heights of 4000, 6000, and even 10,000 feet, as in the Compass Berg in the Sneeuwveld or Snowy range.

75. From this point begins what may be termed the *Eastern system*, consisting of the Drakenberg or Quotlamba Mountains (10,000 feet), the Lupata Mountains (8000 or 10,000 feet), and other ranges that hold northward in parallel lines and increasing altitudes towards the equator, where several of the higher peaks (Kenia and Kilmandjaro, 17,000 and 20,000 feet) are said to be covered with perpetual snow. From the equator, in the direction of Abyssinia, would seem to extend high table-lands of 7000 or 8000 feet, which merge themselves, in all likelihood, into the highlands of upper Ethiopa, and form the great gathering-grounds of the Nile.

Australasian and Polynesian Systems.

76. Of Australia and its mountain-chains it has been already stated (par. 57) that we know too little to enable us to arrange them into groups and systems, though one main ridge, extending along the eastern coast, from Torres Straits on the north to the extreme point of Tasmania on the south, would seem to indicate a sameness and continuity of geological upheaval. This chain consists chiefly of granites and porphyries, intersected and overlaid in many places by recent volcanic products; is extremely rugged and inaccessible on the coast side, but slopes gradually towards the interior, and seldom exceeds 5000 feet in elevation—Mount Kosciusko, 6500 feet, and Sea-View, 6000 feet, in Australia, and Mounts Humboldt and Benlomond, 5520 and 5502 feet, in Van Diemen's Land, being the highest known points of elevation. Of the mountains that occur in the many islands of the Pacific and Indian Archipelago, it may be remarked that they are chiefly active volcanoes, and though often occurring in obvious linear connections, and of great altitudes (6000, 10,000, and 14,000 feet), they are merely to be regarded as chains in embryo, and as the rudiments of systems yet to be elaborated. The Aleutian Isles, the Japan and Kurile Isles, the Philippine and Molucca Isles, the islands of India and Australasia, the Sandwich Islands, the Society Isles, and Marquesas—all form volcanic groups and series of evident central and axial connections; and their results on the geography of future ages cannot fail to be as marked and decided as the influences of the Andes or Alps are on the physical features of the present day. (See Map of Volcanoes.)

American Systems.

77. Having reviewed the mountain-systems of the Old World, we now turn to those of the New, where the arrangements are altogether on a simpler and more uniform plain. In North America we have first the *Eastern, Appalachian,* or *Atlantic system,* so called from its general proximity and parallelism to the Atlantic seaboard. It separates the waters that flow eastward into the Atlantic from those that flow westward into the basins of the Mississippi and St Lawrence; and though trending in one continuous direction from the St Lawrence to the Gulf States, may be said to consist of two divisions—the Blue Ridge, Shenandoah Ridge, and Alleghany on the south, and the Green and White Mountains on the north—sepa-

rated from each other by the narrow cross-valley of the Hudson. In length the system is nearly 2000 miles, has an average breadth of 100 or 130 miles; and though its mean altitude is only about 2500 feet, it yet ascends in Mount Washington in New Hampshire to 6652 feet, in Black Mount between Tennessee and Carolina to 6420 feet, and in Mount Katahdin in Maine to 5360 feet. In the northern section of the system, the ridges of the Notre Dame, the Green, White and Adironbeck Mountains are more or less irregular and interrupted; but in the southern, the Alleghanies consist of several closely parallel chains of great continuity, though frequently cut across by ravines and river-courses. Geologically, the system consists chiefly of the older or palæozoic rocks, flanked on both sides by an extensive development of carboniferous strata; and its eastern slopes comprise some of the finest and most diversified country in the American Union. Separated from the preceding system by the valley of the St Lawrence, but still trending in the same general direction to the northern shores of Labrador, occur the Wotschish and Mealy Mountains, which, though seldom exceeding 1400 or 1600 feet in height, are yet, from their boreal position, for the most part covered with perpetual snow. The following are the culminating points of this Eastern or Atlantic system:—

Mount Washington, New Hampshire,	6652 feet.
Black Mount, Carolina,	6420 ,,
White Mountains, Massachusetts,	6230 ,,
Mount Adams, Alleghanies,	5960 ,,
Mount Jefferson, Alleghanies,	5860 ,,
High Peak, Adironbeck Mountains,	5467 ,,
Katahdin, Maine,	5360 ,,
Notre Dame, Lower Canada,	3768 ,,
Kaatskill, New York,	3454 ,,

78. Interiorly and beyond these eastern ranges the country is one immense plain till we come to the *Western* or *Pacific system*, which, under the familiar name of the Rocky Mountains, stretches in several more or less connected ranges form the Isthmus of Panama to the shores of the Arctic Ocean. This extensive system, which after all is but the northern prolongation of the great backbone of the New World, consists of two main ranges—the Pacific or Oceanic, skirting the western seaboard from Cape Lucas in California to Cape Elizabeth in Russian America—and the Rocky Mountains proper, extending in double and sometimes in treble chains from Panama to the Arctic shores. The former of these ranges forms the watershed between the Pacific on the west and the Colorado, Columbia, and Colville on the east. Though continuous as one great range, it consists of several members, such as the Sierra S. Lucia and Sierra Nevada in California, whose highest

points are Mount St John 8000 feet, and Mount Tsashti 14,000 feet; the Cascade range in Oregon territory, culminating in Mounts Hood and Jefferson 15,000 feet, and Mount St Helens 15,750 feet; and the Sea Alps in the north, having their highest points in Mount Fairweather 14,783, and Mount St Elias 17,850 feet. Geologically, the range is of comparatively recent origin, contains many extinct and dormant volcanoes, and evidently connects itself with the still active series of the Aliaski peninsula and the Aleutian Islands. The latter or Rocky Mountain range forms, on the other hand, the long watershed between the tertiary valleys of the Colville, Frazer, Columbia, and Colorado on the west, and the great Lake region and the plains of the Mississippi on the east. It consists, in like manner, of several members, which, though obeying the same axial direction, yet separate and converge so as to constitute a series of plateaux of varying magnitude and elevation. At the southern extremity of the range we have, *first*, the volcanic chain of Guatemala, rising in the craters of Atitlan and Agua to 12,500 and 15,000 feet; *second*, the clustering or transverse mountains of Anahuac or Southern Mexico, ascending in Orizaba and Popocatepetl to 17,879 and 17,720 feet; *third*, the Cordillera of Cohahuela and Potosi, and the Sierra Verde and Madre, which support the lofty table-land of New Mexico, and ascend in Pike's Peak and Long's Peak to 10,000 and 12,000 feet; *fourth*, the Wind River Mountains between Nebraska and Oregon, attaining, in Fremont's Peak, an elevation of 13,568 feet; and, *lastly*, the northern and parallel ranges of the Rocky Mountains proper, which rise in Mount Hooker to 16,730 feet, and in Mount Brown to 15,970 feet. Geologically, the whole of this vast range is of ancient formation, with the exception of the volcanic mountains of Guatemala and Mexico, and these are evidently portions of the still active development of Central America and the West India Islands. Indeed, the whole of the Pacific system, with the exception of the Rocky Mountains proper, partakes less or more of the volcanic character; with this observed difference, however, that towards the north in the seaward range the igneous forces are becoming more active, while in the inland range the reverse is the case—the only section of activity being in Mexico and Central America. Among the many elevated points of the Pacific system, the following may be given as the higher and better known:—

Orizaba, Volcano, Mexico, . . .	17,879 feet.
Mount St Elias, V., Sea Alps, . . .	17,850 „
Popocatepetl, V., Mexico, . . .	17,720 „
Mount Hooker, Rocky Mountains, . .	16,730 „
Mount Brown, Do., . . .	15,970 „
Iztacihuatl, V., Mexico, ...	15,705 „

Mount St Helens, Cascade Range,	15,750 feet.
Mount Hood, Do.	15,000 "
Mount Jefferson, Do.	15,000 "
Toluca, V., Mexico,	15,168 "
Agua, V., Guatemala,	15,000 "
Tsashti, Sierra Nevada,	14,000 "
Mount Fairweather, Sea Alps,	14,783 "
Amilpas, Guatemala,	13,160 "
Fremont's Peak, Wind River Mountains,	13,568 "
Colima, V., Mexico,	13,000 "
Atitlan, V., Guatemala,	12,500 "
Mount Regnier, Cascade Range,	12,320 "
Mount Taylor, Rocky Mountains,	12,256 "
Wrangell's V., Russian America,	12,064 "

[Referring to the Californian earthquakes of 1856, Dr Trask (in 'Silliman's Journal' for 1857) remarks, that "along the coast of Mexico and Central America to the south of California, from all the records that are obtainable, there appears to have been a much greater exemption from those phenomena than has been usual in former years. This seems to have been the fact also throughout the Pacific, Oceanic, and most of the continental islands along the coast of China; while to the north and north-west beyond the 55th parallel, both volcanic and earthquake phenomena appear to have been more violent than usual. This has been observable for the most part in the neighbourhood of the Aleutian Archipelago, along the north-east coast of Japan, and in the British and Russian possessions of North America on the Pacific, and islands of the Ochotsk Sea."]

79. In South America the pre-eminent system is that of *the Andes,* which extends along the Pacific seaboard from Tierra del Fuego on the south to the Isthmus of Panama on the north—there connecting itself with the onward prolongation of the Rocky Mountains. As a mountain-range the Andes form one of the most definite and persistent on the globe—skirting in unbroken ridges the entire Pacific shore for nearly 4500 miles in length, and varying in breadth from 40 to 350 miles. In some places the range consists of a single ridge; in other places of two or more ridges supporting lofty but narrow plateaux; and in general it presents a steep slope towards the Pacific, from which it is distant from 20 to 80 miles, while towards the east it descends by gradual stages into the broad plains of the Orinocco, Amazon, and La Plata. According to Humboldt, the mean elevation of the Andes is 11,830 feet, and the extent of surface covered by their bases not less than 531,000 square geographical miles. Geologically, the system is composed of granites, greenstones, and porphyries, flanked by metamorphic schists and palæozoic strata, but exhibits throughout a greater number of active craters than any other mountain-chain, and as a consequence is largely crowned and covered, especially on its western slopes, by vast accumulations of lava, scoriæ, and other volcanic products. Though presenting one continuous axis, the range consists of several members known

by the countries in which they occur, as the Patagonian, the Chilian, the Bolivian, the Peruvian, and the Columbian Andes. The Patagonian section consists of a single range of moderate elevation, but ascending in several points (Mount Darwin, Mount Stokes, the volcanoes of Yanteles and Minchinmadiva) to 6400 and 8000 feet. As the snow-line descends in Southern Patagonia to 3000 feet, much of the range is perpetually frozen, and glaciers, unknown in other parts of the Andes, make their appearance in the higher glens and gorges. The Chilian Andes extend, in like manner, in one immense ridge; and though their mean elevation is inferior to those of Bolivia, they yet contain the giant Aconcagua—the culminating cone of the system, and the highest known point in the New World continent. The snow-line in this portion of the system rises from 8000 to 10,000 feet; and high above it, in perpetual winter, rise the lofty peaks of Aconcagua, 23,910 feet; Tupungata, 15,000 feet; and the volcanoes of Chilian and Villarica, 16,000 feet. Next in northward order occur the Bolivian Andes, rising in two parallel ranges—the Cordillera of the Coast and the Cordillera Real—and supporting between them the table-land of Desaguedero, 13,000 feet above the sea, 500 miles in length, from 30 to 40 miles wide, and enclosing Lake Titacaca at an elevation of 12,846 feet. In this, the central portion of the system, the snow-line ascends from 15,000 to 18,000 feet; and high above it, in the western range, rise Sahama, 22,350 feet; Chiquibamba, 21,000 feet; and the volcanoes Gualatieri and Arequipa, 20,000 and 22,000 feet; and in the eastern range Sorate, 21,286; Illimani, 21,140; and Cochabamba, 17,000 feet. Northwards from the Bolivian plateau, which terminates in the Knot of Cusco, the Andes open up into three parallel ridges, known as the eastern, central, and western Cordilleras of Peru—the western being the highest, and separated from the Pacific by a sandy and arid desert 120 miles in breadth. In these Cordilleras the highest points are Sasaquanca in Lima, 17,904 feet; Vilcanota, 17,525; and the Knot of Pasco, 11,800 feet. Leaving the Cordilleras of Peru, which terminate in the Knot of Loxa, we next meet in northward order the Colombian Andes, or the Andes of Quito—a lofty volcanic portion of the system, which rises in double or treble ridges, one main portion extending in the direction of Panama, and another bending north-eastward to the Caribbean Sea. In this region, much of which lies directly under the equator, the snow-line rises to 15,000 or 16,000 feet; and hence all the higher peaks and volcanoes—Chimborazo, 21,424; Cotopaxi, 18,875; Antisana, 19,132; Coyambe, 19,535; and Tolima, 18,120 feet—are covered with perpetual snow. Such are the various portions that constitute the giant system of the Andes—a system which, whether in its extent and linear continuity, its boldness and altitude, its high inhabited table-lands, its mineral riches, or its physical influences, is, even more than the Himalayas, the most remarkable on the globe. As already mentioned, the mean elevation of the Andes (according to Humboldt) is 11,830 feet; upwards of forty points rise above 14,000 feet; and the following twenty points exceed 19,000 feet:—

Aconcagua, Chili, ...	23,910 feet.
Sahama, Volcano, Peru, ...	22,350 „
Parinacota, Peru, ...	22,030 „
Tupungato, Chili, ...	22,016 „
Gualatieri, Peru, ...	21,960 „
Pomarape, Peru, ...	21,700 „
Chimborazo, Columbia, ...	21,424 „
Sorate, Bolivia, ...	21,286 „
Illimani, Bolivia, ...	21,148 „
Chiquibamba, Bolivia, ...	21,000 „
Viejo, Peru, ...	20,500 „
Concæ, Chili, ...	20,386 „
Chachacomani, Bolivia, ...	20,355 „
Hurina, Bolivia, ...	20,260 „
Angel Peak, Bolivia, ...	20,115 „
Chipicani, Peru, ...	19,745 „
Charcani, V., Peru, ...	19,708 „
Coyambe, Columbia, ...	19,535 „
La Mesada, Bolivia, ...	19,356 „
Antisana, Quito, ...	19,132 „
Santa Marta, Venezuela, ...	19,000 „

80. The mountain-system next in importance in South America is that of *Brazil*, occupying the eastern portion of the continent, extending in several parallel ranges from the plains of the La Plata on the south to those of the Amazon on the north, and spreading inland for nearly 1800 miles in a broad plateau, whose mean elevation is about 3200 feet. These ranges or ridges of table-land are separated from each other by the affluents of the Amazon and the St Francisco on the one hand, and by those of the Paraguay and Parana on the other, and succeed each other—ridge and plain—with wonderful continuity. Proceeding from the Atlantic westward, we have, *first*, the Sierra Espinhaço, whose culminating heights are Itambe, 5960; Piedade, 5830; and Itacolumi, 5750 feet; and the Sierra do Mar, or Sea-range, which attains in Morro dos Candos an elevation of 4476 feet; *second*, the Sierra Tabatinga, forking northward into the Irmaos and Sierra Mangabeiros; *third*, the Cordillera Grande, whose chief heights are from 6000 to 7000 feet; and, *lastly*, the Sierra de los Vertentes and other inferior ridges, that gradually descend into the great

central plain of the continent. Geologically, the Brazilian system is eminently primary, consisting of granitic protrusions and crystalline schists rich in the precious minerals and metals; abounding, from the character of its rocks, in picturesque beauty; and from its tropical situation and minor elevation, clothed to the summits with an exuberant and varied vegetation.

81. The last and only other mountain-system in South America is that of *Parimè*, which occupies the oval tract of country lying between the Amazon and Orinocco, and forms the high ground from which descend many of the minor affluents of these gigantic rivers. This plateau, whose mean elevation is from 1600 to 2000 feet, is traversed in an east and west direction by several closely-set ridges (Sierras Acarai, Parimè, Pacaraima, Imataca, &c.), which, though of no great general elevation, yet ascend in Duida to 7149 feet, in Roraima to 7450, and in Mararaca to 10,500 feet. Like the mountains of Brazil, the system of Parimè consists of granitic bosses crested and flanked by crystalline schists, and has not inaptly been described as a primary island rising from the vast tertiary and recent expanses of the Orinocco and Amazon. Lying almost directly under the equator, the higher sierras are clothed with impenetrable forest-growths, while the lower grounds, according to the season, are alternately arid wastes or covered with a carpeting of the most luxuriant grasses.

82. Such are the principal mountains of the world as arranged by geographers into groups and systems. The arrangement may not in every case be a natural one—that is, the mountains composing some so-called "system" may not strictly belong to the same set of geological causations—but the arrangement, such as it is, greatly facilitates reference, and aids our comprehension of the effects produced by any mountain-group on the climate and vital economy of the region in which it is situated. The arrangement has also its topographical advantages, for little can be done in the way of correct description till the objects to be described have been arranged and classified according to some principle of similarity or sameness of origin. But whatever may be the ultimate grouping, we see in mountain chains and systems one of the most important features in the physical machinery of the globe. Rising and falling—here in easy undulations, there in steep peaks and ridges—here in abrupt crags, and there in gentle slopes—they produce a diversity of surface eminently fitted for diversity of vegetable and animal life. Presenting their high ridges to the moisture-laden currents of the atmosphere, they serve as so many points of condensation, producing clouds, mists, and showers that temper the heat in the lower regions,

and refresh and nourish their vegetation. Elevated into regions of perpetual snow, in hot countries they cool the breezes that descend from their heights, while their snows and glaciers become perennial storehouses which, under the summer sun, yield a copious supply to the streams and rivers of the thirsty lowlands. From their geological structure and formation they are necessarily the chief repositories of the precious minerals and metals, and even such deposits as occur in the sands and gravels of their streams have been worn and washed from their disintegrated veins. Their healthy, life-bracing heights have ever been the notable nursery-grounds of active, courageous, and independent races; while their snow-clad heights become boundaries and barriers to naturalism, as well as to the dispersion of plants and animals, more impassable even than the breadths and depths of the ocean. In whatever light they may be viewed—whether as conferring diversity of surface on the land, and consequent diversity among its plants and animals—as intercepting the currents of the atmosphere and condensing its vapours into mists, rains, and snows—as fulfilling the office of gathering-grounds and storehouses to the streams and rivers—or as becoming the great natural barriers between different regions and races,—we see in mountains and mountain-ranges one of the most important parts of the machinery of the globe. Compared with the plains and valleys they may appear rough, barren, and inhospitable; but were it not for their existence, many of the existing plains would become deserts, and all the lower valleys be shorn of much of their amenity and fertility.

Table-lands or Plateaux.

83. Next in importance in the vertical relief of the land are those elevated expanses known as *table-lands* and *plateaux*. A table-land, as the name suggests, is a flat elevated surface; but this idea of flatness must be received only in a comparative sense, for the surface, though plain-like on the whole, is usually diversified by minor undulations and irregularities. Being, in effect, broad mountain-masses, many of these plateaux form the *gathering-grounds* and sources of some of the noblest rivers; while their elevation confers on them a climate and a vegetable and animal life distinct from that of the surrounding lowlands. Others, again, are flat tracts of sand and shingle, partially dotted with verdure in spring and early summer, scorched and desert in summer and autumn, and shelterless, desolate wastes during winter. Whatever their superficial character, they are inseparably asso-

ciated with the mountain-systems, most of these systems not rising in narrow ridges from low-lying plains, but towering above broad elevated regions which seem to be formed and supported by their bases. Thus, on turning to the map of Asia, it will be seen that all the great rivers flow north, south, east, and west from the central region, which consists in reality of a succession of lofty terraces or plateaux. First we have the table-land of Iran or Persia (including large tracts of Beloochistan, Affghanistan, and Bokhara) rising from 2300 to 3500 feet above the sea-level, upwards of 300,000 square miles in area, and presenting throughout a riverless, parched, and desolate region; next in altitude, the great sandy and rainless desert of Gobi, rising from 4000 to 6000 feet, and occupying an area of nearly 400,000 square miles; then, rising on either side of this, towards the centre, the plateaux of Dzungaria and Upper Tartary, less arid and more varied in surface; and, lastly, the still loftier plateau of Tibet, the highest inhabited region in the world, with an elevation of from 11,000 to 15,000 feet, and an area of 166,000 square miles. Besides these great central uplands there are in Asia the lateral and more isolated plateaux of the Deccan, rising from 1600 to 2000 feet in Hyderabad, to 4000 feet and upwards in Mysore; of Arabia, the sandy and arid, varying from 3000 to 6000 feet high, and spreading over an area of more than 700,000 square miles; of Armenia, 7000 feet high, supported by the Taurus and Anti-Taurus, and extending from the Dardanelles to the Caspian; and, lastly, that of Ust Not, between the Caspian and Aral Seas. With the exception of the Deccan and the mountain-platforms of Armenia and Tibet, the whole of these table-lands, from Arabia on the west to Gobi or Shamo (sand-desert) on the east, belong to one great belt of arid and rainless country, sandy and shingly in soil, desert in character, and evidently belonging to the same geological age and formation. Alluding to the ethnological effects of these long desert ranges of high land, it has been remarked by Humboldt, that "they separate the ancient and long-civilised races of Tibet and Hindostan from the rude nations of Northern Asia. They have also exerted a manifold influence on the changing destinies of mankind. They have inclined the population southward, impeded the intercourse of nations more than the Himalayas or the Snowy Mountains of Sirinagur and Gorka, and placed permanent limits to the progress of civilisation and refinement in a northerly direction."

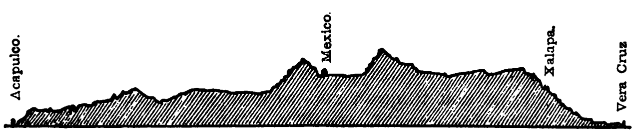
84. In Europe, less elevated and more broken up by seas, we have a smaller development of table-lands, and these generally of limited area, and in the southern or higher division of the continent. The most notable is that of Castile, in Spain, having an elevation

of from 2000 to 2300 feet, and traversed by hilly ridges (sierras) that give great irregularity and diversity to its surface. There is next the less defined upland of Switzerland, from 3000 to 4000 feet in elevation; and, trending north-eastward in the same direction, the lower plateaux of Bavaria and Bohemia, the latter having an elevation of only 900 or 950 feet above the sea. The so-called plateaux of Avergne and of the Scandinavian and Balkhan chains may be regarded as mere mountain-flats, too limited in extent to possess any physical feature, or to exercise any influence distinct from those of their associated ranges. In like manner, what has been termed by some geographers "the Carpathian-Uralian plateau"—that flat open region that stretches between the Carpathians and Urals—may be looked upon merely as the southern belt of the great European plain, more elevated, no doubt, than the rest, but still exhibiting more of the characters of the plain than of the upland or plateau.

85. Of Africa we have too scanty information as yet to speak with certainty respecting the plateaux and mountains that may rise within its interior; but we know that much of the Sahara or Great Desert is of a flat elevated nature (from 1500 to 2000 and 4000 feet), and that inland from the coasts of Congo and Loango the country assumes the character of a lofty table-land. There is also the plateau of Abyssinia (Amhara or Axum), from 7000 to 8000 feet above the sea-level, supported and traversed by several clustering mountain-ridges which form the gathering-grounds of the Atbara and Blue Nile; and, lastly, the *karoos*, or terrace-plains of Southern Africa (already noticed in par. 74) rising stage by stage towards the interior to an elevation of 2000 feet, carpeted with grass during the rainy season, and parched and barren for the rest of the year.

86. In the New World the great superficial contrast is less between mountain and table-land, or plain and elevated upland, than between the gigantic mountain barrier that walls the Pacific from one extremity of the continent to the other, and the low broad plains that stretch eastward from its base towards the Atlantic. Nevertheless, in South America, the chain of the Andes presents several table-flats of vast elevation—the most remarkable being that of Bolivia, a great table-land 120,000 square miles in extent, rising from 11,000 to 12,500 feet above the sea, and early the seat of a busy and wealthy civilisation. Much also of the interior of Brazil partakes of the table-land character, having a mean elevation of 3000 feet, and traversed by the sierras (par. 80) that give feature to that fertile and tropical country. In North America, from the Russian territory on the north to Mexico on the south, there occur a series of elevated

uplands, upborne, as it were, by the parallel ranges of the Rocky Mountains. One of the most remarkable of these plateaux is that comprising the highlands of Oregon and the saline desert or inland basin of Utah, whose elevation is from 4000 to 5000 feet, and the waters of which, having no outlet, form a series of salt lakes, one of which (Utah) is of considerable extent, and almost saturated with salt. Desert and inhospitable as this upland tract undoubtedly is (Colonel Fremont found the water covered with ice every night during the month of August), it seems destined to be the great overland highway between the Atlantic and Pacific States of North America—the ascents on either side being so prolonged and gradual as to be accessible, it is reported, even to railway construction. The most decided of the American table-lands, however, is that of Mexico, not more remarkable for its elevation than for its persistent



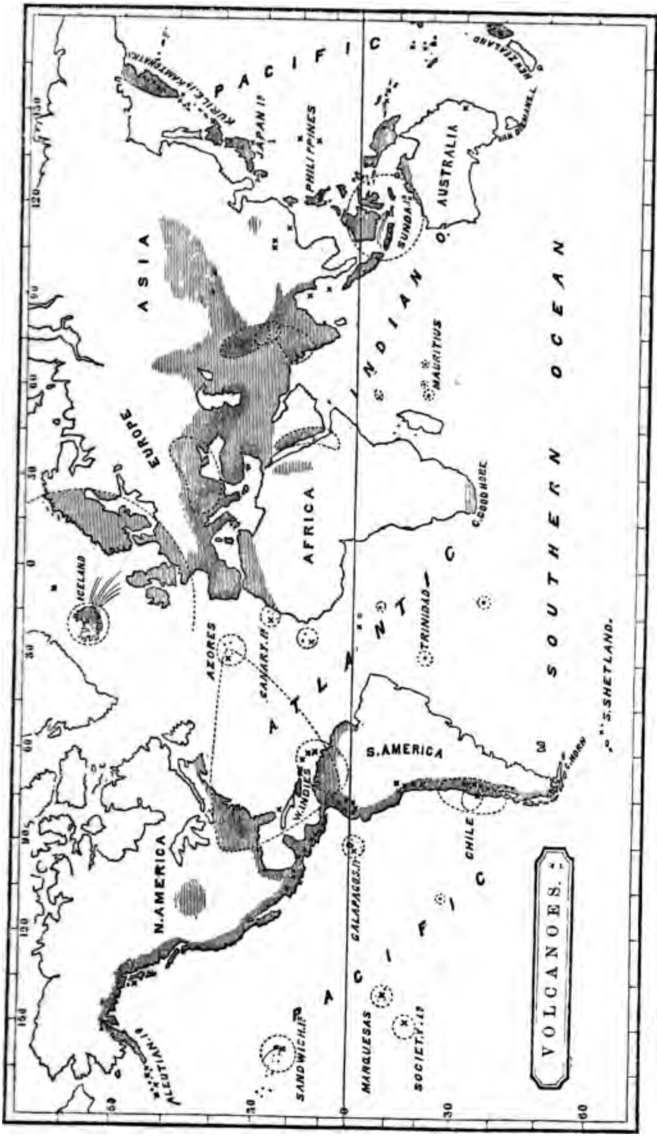
Mexican Table-Land.

extent. "On the eastern and western coasts," says M. Balbi, "are low countries, from which, on journeying into the interior, you immediately begin to ascend, climbing to all appearance a succession of lofty mountains. But the whole country is thus in fact raised into the air from 4000 to 6000 and 8000 feet. The conformation of the country has most important moral and physical results; for while it gives to the table-land, on which the population is chiefly concentrated, a mild, temperate, and healthy climate, unknown in the burning and deadly tracts of low country into which a day's journey may carry the traveller, it also shuts out the former from an easy communication with the sea, and thus deprives it of a ready access to a market for its agricultural productions." As with the Mexican table-land, so in fact with all others of any decided elevation. A distant island in the ocean is not more separated from its contiguous continent, or more strongly marked by its own physical peculiarities, than a high mountain-walled tract raised several thousand feet into the atmosphere is characterised by a climate and vegetable and animal productions unknown in the regions that surround it.

NOTE, RECAPITULATORY AND EXPLANATORY.

In the preceding chapter the attention of the student has been directed to the more elevated portions of the land, as consisting of mountains and table-lands. These mountains have been arranged by geographers into *chains* and *ranges;* and these ranges, again, into *groups* and *systems* that occupy the same contiguous area, and apparently belong to the same series of geological operations. The continuity of mountain-chains has been observed from the earliest times, and hence the antiquity of the names by which many of them are distinguished; but their classification into groups and systems is of recent date, and liable to correction and amendment as clearer and more correct views are obtained respecting the forces on which their formation and elevation depend. There is no doubt that to the vulcanic forces acting in lines or axial directions more or less continuous, we owe our mountain chains and ranges; and to a repetition of such ranges in directions having some degree of parallelism or connection, we give the name of group or system; but what the law that determines the course of vulcanic activity, and regulates its shifting in time from area to area, science can do little more than merely conjecture. That it is the purely dynamical, depending partly on lines of least resistance, partly on the relations of the terraqueous crust to the internal igneous mass, and partly, it may be, to some unknown successional change in the motions of the globe itself, is the most that our present knowledge can suggest—a suggestion that will require long-continued research and exact calculation to carry into the domain of reliable theory.

But whatever the law, its modes of manifestation have been the same throughout all the geological epochs; and we can trace in the structure of the old palæozoic and mesozoic mountains upheavals, accumulations, and disruptions precisely analogous to those that characterise the volcanic hills of the present day. The lines and centres of activity are changed (see Map of Volcanic Action, page 97), and the products of accumulation exhibit a newer aspect, but this is all. We see in the vast cincture of vulcanism that girdles the shores of the Pacific—the Andes, Mexican, and Rocky Mountains on the one side, and the Kamtchatkan peninsula, Japan, Philippine, and Sunda Isles on the other—a mountain-system in elaboration as vast and continuous as any yet described by geography. And when we cast our eyes over the numerous centres of activity which stud the bosom of the same ocean, we



*** The shaded portions indicate the *lines* and *centres* of volcanic activity; the more important volcanoes being marked by a ×.

perceive a power at work sufficient to produce in time a continent of uprise and surface-irregularity as remarkable as any of those that now form the themes of our science. It is thus that geology and geography trace a causal connection between mountains now in course of elaboration and those that belong to tertiary, secondary, and primary eras; and, though now unable to determine the law that regulates their position, may yet, in this way, approximate to its expression.

In the mean time, and for the sake of reference, the mountains of Europe have been arranged into the British, Iberian, Alpine, Scandinavian, Uralian, and Caucasian systems; those of Asia into the Western, South-Eastern, Eastern, and North-Eastern; and those of Africa into the Atlas, Abyssinian, Guinea, Cape, and Eastern systems. In the New World the mountains of North America are usually arranged into the Eastern or Atlantic system, and the Western or Pacific; while those of South America are distinguished as the systems of the Andes, of Parimè, and of Brazil. As to the table-lands, the more important and better known in the Old World are those of Castile, Switzerland, Bavaria, and Bohemia in Europe; and of Armenia, Arabia, Persia, Tartary, Mongolia, Tibet, and the Deccan in Asia. In the New World those of Bolivia and Brazil are the most notable in South America; while in North America the only similar tracts deserving of notice are the table-land of Mexico and the desert uplands of Utah and Oregon.

In whatever form the highlands of the globe appear, whether as linear mountain-chains or as broad-spreading plateaux, they exercise most important influences on climate, and consequently on the distribution of plants and animals. In the torrid zone they afford the climate and produce of temperate regions, and in temperate zones they assume the characteristics of polar latitudes; while everywhere they are the great gathering-grounds of glacier, stream, and river—dispensing their stores to the thirsty lowlands in moderated but never-failing supplies. It must be observed, however, that mountain-chains which run in a latitudinal direction become more certain barriers to the dispersion of plants and animals, and better boundaries between nations, than those that run in a meridional course—the former severing, as it were, the zones of temperature that lie on either side, the latter connecting several zones, the warmer by their lower heights, and the colder by their greater elevations. A temperate flora or fauna may range almost from one end to the other of the Andes; whereas the life north and south of the Himalayas is as much apart as though they existed in different continents.

To the student desirous of following out more fully the study of the mountains and mountain-systems of the globe, and the causes concerned in their upheaval and formation, we may recommend perusal of the various 'Memoirs' of Von Buch and Elie de Beaumont, Hopkins's 'Researches in Physical Geology,' Daubeny's 'Treatise on Volcanoes,' Scrope on 'Volcanoes,' Mallet's 'Seismology,' the chapters on Igneous Formations in Lyell's 'Manual and Principles of Geology,' and Humboldt's 'Personal Narrative;' for descriptions of special ranges and their respective phenomena, such works as Hooker's 'Himalayan Journal,' Forbes's 'Glaciers,' Tyndal's 'Alps and their Glaciers,' Humboldt's 'Narrative,' Fremont's 'Rocky Mountains,' &c.; and to those curious in the matter of mountain measurements, the tables appended to the Physical Geographies of Sir John Herschel and Mrs Somerville will supply the desired information.

VII.

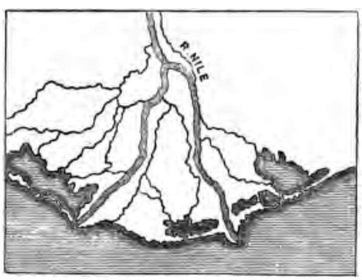
THE LAND—ITS LOWLANDS.

Plains and Deserts.

87. As the higher and more irregular portions of the earth's surface consist of mountains and table-lands, so the lower and more level consist of plains and valleys. The one set of features counterbalances, as it were, the other, and thus contributes to that variety of aspect so pleasing in the landscape, and so indispensable to diversity in its animal and vegetable productions. In a general view, mountain and plain are the direct antithesis of each other, —the former high, cold, rugged, and inaccessible—the latter low-lying, warm, fertile, and everywhere open to the dispersion of plants and animals, and to the settlement and growth of human society. Though the term *plain* is usually applied to level expanses of no great elevation, and is apt to be associated with verdure and fertility, yet several of the great plains of the world are considerably above the sea-level, and present every variety of surface, from green grassy flats to deserts of shingle and loose shifting sand. As mountains were the results of volcanic upheaval continued through indefinite ages, so plains and valleys are the undisturbed portions of the earth's crust, and in most instances represent the beds of former seas, and the silted-up sites of lakes and estuaries. Not only does their general contour convey this impression, but their soil and subsoil reveal their origin, and point to a time when large expanses of ocean occupied the areas of the present plains, and shallow estuaries and chains of lakes the sites of our alluvial valleys. Bearing in mind this origin, it will help to explain certain appearances of soil and surface, and enable us to account for certain distributions of plants and animals that might otherwise remain inexplicable.

88. In treating of the low level tracts of the land, the terms *plain* and *valley* are sufficiently general and well understood, and

are therefore the most frequently employed in geographical description. There are others, however, which refer either to some peculiarity of surface and condition, or are of local origin, and these it may be useful at this stage to explain. Thus the term *prairie*, though simply the French word for "meadow," is usually applied in a technical sense to the open, slightly undulating, grassy plains of North America; *llanos* are the river-plains of tropical South America, alternately covered with rank vegetation, and reduced to a desert by periodical droughts; *selvas* (Lat. *silva*, a wood), the higher tracts of the same region, densely covered with natural forest-growth; and *pampas*, the treeless but grassy plains of the Parana and La Plata. The term *steppes* is applied to the plains of northern Asia, generally covered with long rough herbage, but also partially wooded, and not unfrequently shingly and desert; *tundras* to the boggy, frozen flats of Siberia and northern Russia; and *tarai* to the belt of unwholesome jungle that lies between the plain of Hindostan and the Himalayas; *Sahara* is the long-established and familiar name for the great, arid, and sandy desert of northern Africa; while *karoo* is applied to the open flats in the southern region of the same continent, which are hard and arid in the dry season, but carpeted with grasses and flowers during the periodical rains. In Britain the terms *dale* and *vale* are usually applied to minor river-plains; *strath*, in Scotland, to any wide stretch of generally flat-lying land; and *carse*, to those level alluvial flats that occur in connection with existing estuaries, and which have evidently been reclaimed from their waters either by the ordinary process of silting, or by partial upheaval of the land. The term *delta* is also largely applied to the alluvial land formed at the mouth or rather *mouths* of a river, such as that of the Nile, which first received this name from the resemblance that the triangular space enclosed by its two main mouths bears to the Greek letter Δ or *delta*. Other terms than the above are still more local and restricted in their application, and will be better explained in the text, or in the Glossary, to which the student should make regular and systematic reference.



Nilotic Delta.

89. The principal plain in the Old World is that usually known to geographers as the *Great Northern Plain*. It may be roughly sketched as commencing with the shores of Holland on the west, and extending eastwards through Prussia, Poland, Russia, and Siberia, without any very marked interruption save the intersecting range of the Uralian Mountains. In width it stretches from the shores of the Arctic Ocean almost to the base of the Carpathians in Europe, and to the table-land of Persia and the flanks of the Altai Mountains in Asia—thus occupying between 4,000,000 and 5,000,000 square miles, or nearly one-third of the entire area of these continents. While it slowly rises from the Arctic shores towards the interior, as may be seen by the courses of all the great northern rivers, it may be traversed from east to west (if we except the Uralian range) without changing the level more than three or four hundred feet. In Europe this vast expanse is usually subdivided into the *Germanic plain* on the west, and the *Sarmatian plain* on the east; while in Asia it comprises the *Steppes of Kirghis, Ishim,* and *Baraba,* on the west, and the *Siberian plain* on the north and east. Each of these subdivisions is necessarily characterised by its own peculiarities of soil, situation, and climate, and may therefore be briefly described in detail.

90. Thus the Germanic section includes the low-lying polders and morasses of Holland, and the sandy boulder-strewn plains of northern Germany and Prussia—partly under cultivation, and partly occupied by extensive heaths and open pastures. Throughout, the surface is little varied, and the elevation inconsiderable, some portions of Holland being even under the tide-level, and protected by sea-walls and embankments. The Sarmatian section, on the other hand, occupying a larger area and extending over a wider range of latitude, presents a greater diversity of character, and may be said to consist, in northern Russia, of cold, swampy, and partially-wooded flats; in middle Russia, of moderately temperate, fertile, richly-wooded, and undulating tracts; and, in the south, of indifferent grassy steppes, river-swamps, and saline deserts. Throwing out of view the unimportant heights of the Valdai Hills, the maximum elevation of the middle or Moscow portion is only about 480 feet, from which the plain imperceptibly declines towards the Arctic Ocean on the one hand, and towards the Caspian and Euxine on the other. Towards the eastern extremity of Europe, and especially after passing the Dnieper, the great plain assumes the character of, and passes by degrees into, the steppes of Kirghis, Ishim, and Baraba. These steppes present, as the name implies, wide, treeless, monotonous tracts covered with rough grass and shrubs during a brief season, but soon converted

into arid deserts by the drought of summer, and into bleak, shelterless wastes by the storms of winter. Though they are all open, flat, and treeless, these steppes differ considerably in aspect according to the nature of the soil of which they are composed—some tracts consisting of deep black earth (*tchornozem*), clothed with shrubs and grasses—others of hard, sandy clay, and sterile—and others, again, of sand or rocky shingle, and only here and there dotted with vegetation. This applies, however, only to the spring and early summer; for during the droughts of summer all are alike desert save round the springs and runnels of water, and during winter, which comes on in October, the whole is one exposed and inhospitable snow-waste. The Siberian plain, as might be expected from its extent, is of a more varied character, consisting of low-lying *tundras*, or black swampy peat-mosses, of broad undulating steppes, and partially-wooded uplands. In summer (from June till the middle of August), the tundras are thawed to a small depth, the steppes are scantily covered with grass and mosses, and the banks of the great rivers and uplands are green with the birch and pine; but during the long winter, frost and snow reign supreme, and the whole plain is one dreary and inhospitable wilderness. Geologically, much of the Siberian plain is of very recent origin—its frozen sands and gravels, overlaid by still increasing tundra, containing the remains of mammoth, rhinoceros, and other animals, in wonderful preservation; and if observation be correct, is still on the increase, through that slow uprise of the land which is taking place within and all around the shores of the Arctic Ocean.

91. The secondary plains of the Old World, though of minor extent, are not without their decided influences on the physical and vital phenomena of their respective regions. Among those in Europe may be noticed the *plain of France*, comprising the conjoined low grounds of the Seine, Loire, and Garonne, and rising in its highest parts to little more than 400 or 450 feet; the basin-shaped *plain of Hungary*, watered by the Theiss and Danube, undulating in many parts, and sometimes spoken of as the "European Pampas;" the *plain of Wallachia*, on the lower Danube, fertile but swampy; the *steppe of Astrakhan*, lying along the Caspian and Volga; and the still more restricted but locally important plains of Ireland, Denmark, Andalusia, and Lombardy. Among the secondary plains in Asia may be noticed those of China, Hindostan, Turan, and the Euphrates. The *great river-plain of China*, said to occupy nearly 200,000 square miles, is alluvial throughout, and still on the increase by the silting-up of the Yellow Sea, is crossed in every direction and irrigated by canals,

and is the fertile seat of the oldest, most industrious, and most numerous population on the face of the globe. The *plain of Hindostan*, stretching from the base of the Himalaya to the Deccan, and from the Ganges to the Indus, is also low-lying and alluvial, abundantly fertile under irrigation, and only light and sandy in the district of "the Thur" or the lower Indus. The lowest portion of the plain is that of Bengal and along the Ganges, which, during the rainy season (June to September), is largely inundated; the most fertile and healthy is that of the Punjab, or country of the five rivers, watered by the main tributaries of the Indus; the most desert, that of the Thur, from 300 to 400 miles broad, and consisting of a hard clayey subsoil overlaid by arid shifting sands; and that portion known as the "Run of Cutch," about 7000 square miles in area, is alternately a sandy desert and covered by the waves of the sea. Enjoying every variety of climate from tropical heat and moisture to the mild salubrity of southern Europe—partially inundated during the rainy season, verdant with luxuriant growth after the rains, and largely parched and dusty during the season of droughts, there are few regions that present such diversity of aspect as the great Indian plains, or have been so long the seat of civilised populations and shifting empire. Besides these larger Asiatic low grounds, there may be noticed the *plain or steppe of Turan*, which extends along the southern shores of Lake Aral westward to the Caspian, and is fertilised by the waters of the Syr and Amoo; and the historic *plain of Mesopotamia* (Gr. *mesos* and *potamos*, between or in the middle of the rivers), that stretches between the Euphrates and Tigris southward to the shallow waters of the Persian Gulf.

92. In Africa, with the exception of the Sahara or Great Desert, which may be described as a vast expanse of arid sands and shingle, with an occasional oasis of life and verdure, we know of no continuous plains like those of Europe and Asia, though several minor flats and deltas give diversity to its generally unbroken and monotonous seaboard. The surface of the Sahara is not, however, as at one time supposed, a uniform plain of burning and drifting sands, but presents considerable diversity both in composition and altitude. Some portions are low and flat; others sink, it is said, even below the sea-level; while many rise, in bare broad plateaux, 1000, 2000, and 3000 feet above the surrounding surface. Immense tracts are shingly and saline, others consist of loose drifting sand, occasional patches are rocky and scantily covered with thorny scrub, while at distant intervals over the arid waste some spring or surface retention of water gives birth to an *oasis* or islet of vegetation. This great desert, stretching from Marocco on the west to the valley

of the Nile on the east, is prolonged, as it were, eastward and northward through Arabia, Persia, and Tartary to Mongolia, where it terminates in the equally arid and sandy desert of Shamo—the whole tract from the Sahara to Shamo pointing at once to similarity of conditions and sameness of geological origin. The minor low grounds of Africa, sufficiently known to geographers, are those on the lower courses of the Senegal and Gambia—Senegambia; the swampy and jungle-clad delta of the Niger; and the fertile, periodically-inundated delta and valley of the Nile, which, for four or five thousand years, has been the classic site of industry and civilisation.

93. Respecting Australia—the only other region in the Old World sufficiently extensive to admit of plain-lands—we are yet too scantily informed to offer any definite opinion as to the nature of the interior, though recent discovery would seem to indicate that, instead of a vast scrubby and waterless plain, there is much practicable country, grassy flats, green forests, and river creeks, lying along the routes of the adventurous explorers. Towards the north (Gulf of Carpentaria) the character of the land gradually improves, while towards the south (South Australia) we have every diversity of soil and surface. "There is no country," says the Rev. J. E. Woods, "more interesting in its formations, or more varied in its mineral productions, than South Australia; lofty mountains, extensive plains, sandy deserts, and inland seas, are all included in its far-stretching boundaries. With a climate like that of the south of Spain, it possesses the scenery of the Highlands in some places, while in others deserts like those of Arabia, and vying with them for bleakness, aridity, and burning heat. There are chains of salt lakes which render unprofitable a larger area than England; there are marshes and salt swamps more dank, unwholesome, and extensive than any in the United States; there are rocky precipices and chasms and waterfalls to rival almost the Alps; there are extinct volcanoes of large dimensions, almost as numerous as those of Auvergne; and, finally, there are caves which exceed in magnitude the Guachero caves of Humboldt, or in stalactites the Antiparos of the Ægean Sea."

94. Turning next to the New World, we find the plains on a much more conspicuous and decided scale, stretching more continuously, and rising less above the level of the ocean. In North America the *Great Central Plain,* lying between the Rocky Mountains on the west and the Alleghanies on the east, extends, it may be said, from the Arctic Ocean to the Gulf of Mexico, a distance of nearly 3000 miles. Throughout this long course it is only once interrupted by the gently swelling prairie grounds (1500 or 1600 feet in height),

that turn the courses of the Red and other rivers to the north, and those of the Missouri and Mississippi to the south. Varying, in wide expanses, from 100 to 600 and 800 feet in elevation, it presents considerable diversity of surface—swampy marsh, grassy prairie, forest-land, and barren ground. The most notable feature in the surface of this great central plain, which occupies an area of nearly 3,000,000 square miles, and has been characterised by Humboldt as "an almost continuous region of savannahs and prairies," is undoubtedly that of the open, slightly undulating, and grassy portions denominated *prairies*. These prairies are of vast extent: some are rolling, others are flat and level in surface; many of them are treeless, and covered only with luxuriant grass and flowers; towards the south some tracts verge into shrubby woodland; while in the extreme north the soil is largely swampy and desert. The only other notable lowland in North America is the *Atlantic plain*, lying between the Alleghanies and the Atlantic—a district of little elevation, and often flat and swampy, especially towards the south (*e.g.*, Dismal Swamp), in Georgia and Florida.

[The Dismal Swamp, which may be taken as a type of swamps and morasses in whatever region they occur (always making allowance for the climate and vegetable productions), is thus alluded to by Sir Charles Lyell in his 'Travels in North America:' "It bears the appropriate and very expressive name of the 'Great Dismal,' and is no less than forty miles in length from north to south, and twenty-five miles in its greatest width from east to west, the northern half being situated in Virginia, the southern in North Carolina. I observed that the water was obviously in motion in several places, and the morass has somewhat the appearance of a broad inundated river-plain, covered with all kinds of aquatic trees and shrubs—the soil being as black as a peat-bog. . . . It is one enormous quagmire, soft and muddy, except where the surface is rendered partially firm by a covering of vegetables and their matted roots; yet, strange to say, instead of being lower than the level of the surrounding country, it is actually higher than nearly all the firm and dry land which encompasses it; and to make the anomaly complete, in spite of its semi-fluid character, it is higher in the interior (to the extent of ten or twelve feet) than towards the margin. . . . The soil of the Swamp is formed of vegetable matter, usually without any admixture of earthy particles, and numerous trunks of large and tall trees lie buried in the black mire."]

95. In South America we are presented with three well-marked and distinctive river-plains—viz., those of the Orinocco, the Amazon, and the La Plata. The first is one of the lowest and most level tracts in the world, rising not more than 200 feet at the distance of 500 miles from the sea, and throughout that course marked by swamps, periodically overflowed grass-flats (*llanos*), and tropical forest-growths. The llanos occupy an area of about 160,000 square miles, which is almost wholly inundated during the rainy season, but shortly afterwards is so densely covered with luxuriant grasses that it is known to the natives as the "sea of

grass." During the ensuing tropical droughts, these llanos become parched and withered ; hence the frequent conflagrations to which they are subject, and hence also, in a great measure, the perpetuation of their treeless character. The second or Amazonian plain, still more extensive and unique, is characterised by similar grassy plains and forest-growths (*selvas*), and is the largest river-basin in the world, occupying an area of about 1,500,000 square miles. Richly alluvial in soil, periodically inundated, and under the influences of a tropical sun, these selvas present the rankest luxuriance of primeval forest-growth, and are in many places so densely tangled with undergrowth that they are only accessible by the river-courses that traverse their areas. The third, comprising the contiguous basins of the Uruguay, Parana, La Plata, and Colorado, embraces an area of not less than 880,000 square miles, and is characterised chiefly by its deep alluvial soil, broad thistly flats, and grassy pastures, known as *pampas*. Stretching from the flanks of the Andes to the shores of Buenos Ayres, and thence southwards to the deserts of Patagonia, these pampas differ considerably in character, being flat and thistly towards the coast, slightly undulating and grassy towards the interior, and full of bogs and swamps and scrubby ridges as we approach the Andes. The whole region is treeless, verdant during the rains, but withered and parched during the dry season. The desert terrace-land or steppes of Patagonia, extending southward from the Rio Colorado to the extremity of the continent, is a sterile undulating region—the soil shingly and strewn with boulders, the grass stunted, and the climate cold and tempestuous.

Valleys and Minor Depressions.

96. Besides the great plains of the world, there are numerous valleys and minor low-lying tracts that exercise a decided influence on the soil, climate, vegetables, and animals of the countries in which they occur. These are the *dales* and *vales* of existing streams and rivers, the *basins* of lakes and rivers, and the *straths carses*, and *deltas* of our estuaries. Whether they have been formed by subsidences of the earth's crust, by the silting-up and drainage of lakes and morasses, or by the slow erosive power of rivers (*valleys of erosion*), their characters are much alike, and the purposes they subserve identical. Their low-lying situations, their tempered climates, their rich soils and well-watered surfaces, have ever rendered them the grand nurseries of vegetable and animal growth ; and this fertility and amenity has ever attracted the

human race, and rendered them the main theatres of industry and civilisation. To particularise the lesser valleys—the dales and vales that confer amenity and richness on the land-surface—would be merely to enumerate the rivers and streams that flow through the different continents. Every stream has in some part or other of its course its strip or patch of valley-ground; and these occur of every extent, from the meadow of a few acres to the dale of many leagues; at all altitudes, from the polder and fen, protected from the tides by embankments, to the valley high among the mountains; and in every variety of surface—morass, silt, sand, gravel—from the warp of the latest flood to the greensward of a thousand centuries. In civilised countries these lowlands are the principal seats of culture and husbandry, while in semi-civilised regions they constitute the pasture-lands of the nomadic shepherd and herdsman.

97. Besides the dales and vales and valleys properly so called, there are also the deltas of many rivers—low-lying tracts still in course of formation, and which, from their swampy and partially inundated character, can scarcely be said to belong to the domain of the land. To this category belongs much of the deltas of the Nile and Niger, the Indus and Ganges, the Mississippi, and the Orinocco and Amazon. The older and higher portions of these deltas have long since been converted into fertile alluvial plains, but the lower portions consist largely of mud-flats, sandbanks, and lagoons, partially covered with jungle-growth during the dry season, yet inundated as far as the eye can reach during the periodical overflows of their rivers. In fact, it is the low, level, and sedimentary nature of these deltas that compels the rivers to seek their way to the sea by many *mouths* or outlets—these outlets being alternately silted up, shifted, bifurcated, and converted into lagoons and reaches, according as the flood or sediments prevail. In course of time, however, the existing mud-flats and sandbanks, increasing and consolidating, will be converted into alluvial land, and other banks and shoals will arise as new sediments are carried forward into the area of the ocean. We have here alluded merely to the larger and more notable of deltas, but the student must remember that every river that carries down sediment is forming to some extent a deltic accumulation at or near its embouchure—and this whether in lakes, like the Rhone in Lake Geneva—in inland seas, like the Po in the Gulf of Venice—or in the ocean itself, as the Niger and Amazon. Besides these river-deltas properly so called, there are also considerable low-lying tracts of marine silt and sand-drift, formed, and still forming, along many of the more sheltered bays and recesses of the ocean. These, like the *links* of

our own islands, the *landes* of France, the *dunes* of Holland and Denmark, the *fens* of England, and the *swamps* of Florida, are gradually on the increase, and in process of time assume a flat or plain-like surface.

98. As there are plains and valleys at considerable elevations, and others again scarcely raised above the overflow of the tides, so there are several areas of the land-surface depressed even beneath the general level of the ocean. Laying aside some tracts of the Sahara which are said to sink beneath the sea-level, the most remarkable of these ascertained depressions are the Aralo-Caspian basin, and the trough of the Dead Sea. The former of these, in which are situated the Caspian and Aral seas, is a depressed area of 162,000 square miles in extent, and all considerably below the ocean—the surface of the Caspian, the lowest portion of the cavity, being actually 83 feet beneath the level of the Black Sea. The latter, though a mere trough in comparison with the former, is still more remarkable for its depression—the Dead Sea being no less than 1312 feet lower than the Mediterranean, from which it is 50 miles distant, and separated by the mountain-range of the Lebanon. Whatever the origin of these cavities—whether by subsidence of their areas or by upheaval of barriers that cut them off from the general ocean—it is clear that were their river-supplies not fully counterbalanced by evaporation they would in process of time become filled with water, and their surplus find an outlet by the lowest course to the sea. The Aral and Caspian would be discharged into the Euxine over the low steppes of the Volga and Don; while the waters of the Dead Sea would find their way to the Gulf of Akaba, in the Red Sea, with which, at some former period, it was evidently connected by the dry stony valleys or "wadies" that now lie between.

Origin and Characteristics of Lowlands.

99. As the terrestrial *highlands* — the mountains and table-lands of the world—owe their origin chiefly to the elevatory forces of vulcanicity, so the *lowlands*—the plains, deserts, and valleys—depend for their formation mainly on the levelling effects of water. Many of the larger plains are but old sea-beds—shoals and banks and marine plateaux—that have been gradually elevated above the waters; others are the accumulated silts of shallow seas and bays; while some, again, have been formed by the slow alluvial increment of river-deltas. Of the minor plains and valleys, many

occupy the sites of former estuaries, partly silted up and partly upraised; others, the areas of lakes and morasses now converted into dry land by the double process of silting and drainage; while others, again, have been formed by the erosive and levelling operations of rains, streams, and rivers. Wherever we have a flat and uniform surface of any extent, there, we may rest assured, the smoothing and levelling powers of water have been exerted, and this whatever the nature of the soil and subsoil, whether rich alluvial silt, vegetable earth, clay, sand, gravel, or loose stony shingle. The superficial aspects of these lowlands have, of course, been considerably changed since their first formation, and are still undergoing modification under the influence of meteoric and aqueous agency. Wet and swampy marshes have been and are still being converted into dry land by the accumulation of vegetable soil; slimy mud-flats clothed with verdure and forest-growth; flat and uniform surfaces grooved and furrowed by water-channels; and sandy plains blown into shifting dunes and ridges. The general features may long remain with little perceptible alteration; the minor changes are incessant and interminable.

100. The main characteristics of plains and valleys, as compared with mountains and table-lands, are—1. Their low-lying situations, which, latitude for latitude, confer on them a milder climate, and thus permit the growth of plants that refuse to flourish at higher elevations; 2. Their soil and subsoil, which, for the most part, consist of loose detrital and alluvial matter, favourable also to vegetable growth as compared with the hard rocky structure of hills and mountains; 3. The general tendency of their soils to be further increased and renewed by fresh detritus borne by streams and rivers from the adjacent highlands; 4. The favourable nature of their surface for the formation and increment of rivers by which they are usually traversed; and, 5. Their uninterrupted facilities for the dispersion of plants and animals, their accessibility by river-navigation, their amenity for culture, and, unless where rendered sterile by cold or desert by drought, their general fitness for the purposes of human settlement and civilisation. These and similar characteristics, which will readily suggest themselves to the reflecting student, sufficiently distinguish the lowlands from the highlands of the terrestrial surface, and render still more apparent the intimate union that everywhere subsists between the vital and physical in the scheme of the universe.

NOTE, RECAPITULATORY AND EXPLANATORY.

In the two preceding chapters we have endeavoured to present an outline of the superficial features of the land, as composed of mountains and table-lands, of plains and valleys, and the relation they bear to each other in the scheme of Physical Geography. Whatever be the geological law that regulates the successive upheaval and submergence of large tracts of the earth's crust, we see in the arrangement of the present continents the more violent effects of the earthquake and volcano in producing abrupt and mountainous irregularities, and the more gradual efforts of air and water in moulding into uniformity of surface its plains and valleys. Whatever be the nature of the vulcanism acting from within, we see that it exerts itself along certain lines and in definite centres, and these lines and centres give rise to mountain chains and groups, and these again give contour and configuration to the terrestrial areas. In the Old World, as already stated, the main axis of elevation is from east to west; hence the greatest length of the continent in this direction, and hence, also, the determination of the rivers and river-plains in northerly and southerly courses from this axis. In the New World, again, the main line of elevation is from south to north; hence, also, the corresponding direction of that continent and the opposite courses of the principal rivers. As with the main continental masses so with the minor spurs and peninsulas—their direction of greatest length being invariably regulated by the direction of their hills. Geology thus becomes the obvious groundwork of geography; and on reference to the Geological Map of Europe, for instance, it will be seen that all the granitic, trappean, and volcanic outbursts are but expressions, in other terms, for the extent and directions of the mountains of that continent. As the great plains are but the undisturbed portions of the continents, they will naturally take the same main direction as the mountain-ranges; just as the table-lands which are upraised by the mountains will be situated among their groups or along their axes. On the other hand, the rivers, obeying the laws of descent from the opposite sides of these axes, will have their valleys and dales running less or more in cross-courses, thus giving additional features of diversity to the land.

Mountains and table-lands, plains and valleys, are thus but the counterparts of each other; and rugged and inhospitable as the former may seem, the latter would be but thirsty deserts were it not for the clouds and rains, the streams and rivers, that are generated among their summits, and descend in perennial supplies from their glens and recesses. Botanically and zoologically, mountain and plain has each its own peculiarities and numerical abundance of forms—these forms becoming fewer and of less importance as we ascend, and more abundant of higher biological value as we descend into the sheltered and fertile lowland. Ethnologically, as mountain regions have ever been the nursing fields of hardy, brave and independent races; so plains and valleys have ever been the chosen seats of settled industry and civilisation. The plains of China and Hindostan, of the Tigris, the Euphrates, and the Nile, were the early and populous abodes of mankind in the Eastern hemisphere, just as in the Western the valleys of the Missouri and the Mississippi were the chosen grounds of primitive mound-building races. And as in former ages, so even now the principal sites and centres of industry are to be found in the river-plains of the Old and New Worlds—the causes that induced the early shepherd settlers being equally operative on their agricultural, city-dwelling, mechanical, and commercial descendants.

There is no special work devoted to the plains and valleys of the world; but such books as Humboldt's 'Views of Nature,' Balbi's 'Geography,' and the like, contain many isolated descriptions; while books of travel may be consulted for particular accounts of the lowlands in the countries to which they refer. Indeed, the true student of geography will rarely neglect the opportunity of perusing the works of competent travellers, as it is only by such means that he can ever become acquainted with the features of the world in general. No one can know the whole world from his own experience, but it is in the power of every intelligent individual to learn something of its principal aspects by a perusal of the reliable and recorded labours of others.

VIII.

THE WATER—ITS OCEANS AND SEAS.

Their Area and Configuration.

101. HAVING considered the various conditions of the Land—its area, configuration, highlands, and lowlands—we now turn to those of the Water, as exhibited in its oceans and seas, their areas, depths, composition, tides, currents, and kindred phenomena. And here it may be observed of WATER, which forms so important an element in the constitution of the globe, that, chemically speaking, it is the *protoxide of hydrogen,* consisting of two volumes of hydrogen and one of oxygen, or of eight parts of oxygen to one of hydrogen by weight—88.9 oxygen and 11.1 hydrogen. When pure and at ordinary temperature, it is fluid and amorphous, without taste or smell, colourless in small quantities, but in large masses of a peculiar bluish-green or blue. The specific gravity of pure or distilled water, at 62° Fahr., is assumed at 1.000, and is taken as the standard of gravity for all other bodies; but sea-water varies, according to locality and the depth from which it is taken, from 1.027 to 1.029. When heated to the temperature of 212° Fahr. at the level of the sea, and under the ordinary pressure of the atmosphere, water boils, and is converted into steam; and this *boiling point* (as it is termed) becomes less as we ascend above the sea-level. In other words, as the pressure of the atmosphere becomes less, *ebullition*, or the phenomenon of boiling, takes place sooner, and this so uniformly that it is taken, like the barometer, as a measure of ascent or altitude. The effects of boiling at the sea-level, and boiling at an elevation of 12,000 feet, are, however, two very different things: what would be cooked by the former heat, might remain unchanged for hours under the influence of the latter. At 40° Fahr. water is at its minimum volume, expanding as it rises above that temperature, till it is wholly converted into vapour, and also, as it falls below it, till at 32° for

fresh, and 28¼° for salt water, it is converted into *ice*—a transparent, brittle, crystalline solid, which floats on the surface.

102. Water, as found on the earth, is never absolutely pure, but contains more or less of various substances, as atmospheric air, carbonic acid, nitrogen gas ; silica, alumina, and salts (carbonates, sulphates, nitrates, phosphates) of lime, magnesia, soda, potash, protoxide of iron, manganese; or chlorides and fluorides of their metallic bases; and in the sea and some saline springs, also iodine and bromine. Like all other fluids whose particles are free to arrange themselves, water at rest always assumes a level surface, and this surface, in the case of the ocean, corresponds with and forms part of the circumference of the globe. As an agent in nature, it is indispensable to the life of plants and animals ; it enters into the composition of all bodies, whether organic or inorganic, and in the form of rain, streams, rivers, waves, tides, and currents, is the great modifier and remodeller of the geological aspects of the globe. Water, in fine, is everywhere—in the atmosphere, in visible or invisible form; in the tissues of plants and animals; and in the substance of the rocks and minerals that compose the solid crust. It is the great solvent and circulatory medium in nature, without which life would be impossible, and the inorganic world deprived of its main modeller and modifier.

103. It has already been noticed (par. 41), that though encircling the globe on every side, and spreading over nearly three-fourths of its surface, the great "world of waters" is more or less configured into certain expanses which are termed *oceans*, and thus we have on the west of the Old World, and between it and the New, the *Atlantic* Ocean; while on the west of the New World, and between it and the Old, spreads out the still vaster area of the *Pacific*. These divisions become apparent on the most cursory inspection of the map of the world—the former lying like an irregular valley between the two continental land-masses, and communicating freely with the arctic and antarctic waters; the latter narrowed to a mere strait on the north, but spreading out towards the south over nearly half the globe, and ultimately losing its individuality in the undefined expanse of antarctic waters. Besides the Atlantic and Pacific, the *Arctic* and *Antarctic* constitute well-recognised though imperfectly known oceans; while between Africa and Australasia stretches the familiar and much-traversed area of the *Indian* Ocean. In treating of these great oceanic expanses, various names and subdivisions are employed by navigators, but for all practical purposes in physical Geography the terms North and South Atlantic, North and South Pacific, Arctic, Antarctic, and Indian Oceans, are sufficiently ex-

plicit and comprehensive. Or, looking upon the waters that extend southwards from the extreme points of Africa, Australia, and South America, as one great united mass, the term *Southern Ocean* will often be found to be convenient, and not inappropriate.

104. Taking the Atlantic Ocean as extending from the arctic to the antarctic circle, its length is upwards of 9000 miles; its breadth varies from 900 to 4000 miles, being only 900 between Norway and Greenland, 1700 between Sierra Leone and Brazil, and 4100 between Marocco and Florida; and its computed area is about 25,000,000 square miles. This vast expanse is little interrupted by islands; in its northern section it is irregular in form, and throws several important branches into the land; but in the southern its form is regular, and its shores continuous. Towards the north it is partly enclosed by the rocky coasts of Greenland, Iceland, and Norway; but towards the south it is quite open, and merges broadly into the Antarctic Ocean. The leading branches are Baffin and Hudson Bays, the Gulf of St Lawrence, Bay of Fundy, Gulf of Mexico, and the Caribbean Sea, on the west or American side; and on the east or Old World side, the North Sea, Baltic Sea, English Channel, Bay of Biscay, the Mediterranean Sea, and the Gulf of Guinea. All, or nearly all, of these recesses occur in the northern division of the Atlantic; hence the greater interest of this section to the geographer, naturalist, and navigator.

105. Of the minor seas or ramifications belonging to the Atlantic (some of which are ice-locked for a considerable portion of the year, and others encumbered by reefs and shoals), the most important, physically and vitally, is the Mediterranean, whose shores formed the early nurseries of civilisation and commerce, and whose waters are still the highway of communication, not merely between the three continents—Europe, Asia, and Africa—that encircle its shores, but between these and every other portion of the globe. "The political and social events which have occurred on the shores of this remarkable part of the ocean," says Admiral Smyth, "are closely connected with the history of almost every country in the world; but independently of its classical and historical associations, the Mediterranean still confers invaluable advantages upon the numerous occupiers of its coasts, and through them on the interior of the surrounding continents. It is, moreover, the great bond of intercourse between the nations of Europe, Asia, and Africa, although it appears as if it had been destined to keep them asunder. Beautifully diversified with islands, and bounded by almost every variety of soil, its products are proportionally various; and from its communication with the Atlantic, it facilitates

commerce with every part of the globe. Here navigation made its earliest efforts; and the comparative shortness of the distances between port and port, by rendering the transit easy even to imperfect vessels, tended to promote and diffuse civilisation; it being an unquestionable axiom that whatever is calculated to make men better acquainted with each other, whether the inhabitants of distant lands or neighbours, must invariably produce beneficial results for the whole."

106. The Pacific Ocean, though less important as a highway of commerce, occupies nearly twice the expanse of the Atlantic—its greatest breadth being 12,000 miles, and its computed area about 50,000,000 square miles. Unlike the Atlantic, it is almost entirely shut out from communication with the Arctic Ocean—the only passage of connection being that of Behring Strait, not more than 36 miles in width, with a maximum depth of 25 fathoms; but, like the Atlantic, it also opens out towards the south, and merges undefinedly into the Antarctic. It is thickly studded with islands and clusters of islands, and these physically and vitally constitute one of its most distinctive features. Its leading branches are the Sea of Kamtchatka, Sea of Okhotsk, Sea of Japan, Yellow Sea, and Chinese Sea, on the west or Asiatic side; while on the east or American side, the Gulf of California and the small bay of Panama are the only indentations that break the uniformity of its coasts. The most important of these minor seas are those of Japan and China, whose shores have been the seat of an early and peculiar civilisation, and whose waters have long been traversed by the ships of every other nation.

107. The Indian Ocean, stretching between Africa and Australia on the one hand, and between Asia and the Southern Ocean on the other, is upwards of 4000 miles in breadth, and is computed to have an area of about 17,000,000 square miles. If we except the Indian Archipelago, which forms its boundary rather than belongs to it, it is encumbered by few islands; and it also penetrates the land by few branches—the Red Sea, Arabian Sea, Persian Gulf, and the Bay of Bengal, being the only minor seas—and these all on its northern or Asiatic boundary. The most important of these minor branches are the Red Sea and the Bay of Bengal—the former early and intimately connected with the history of man, and the latter, the leading highway of modern commerce to the varied wealth of India.

108. The Arctic and Antarctic Oceans, from their circumpolar situations, are largely blocked up with ice, and consequently but imperfectly known to geography. The Arctic forms, as it were, a circular basin, bounded in general by the northern coasts of

Europe, Asia, and America, which remarkably conform to the parallel of 72°, and having an area roughly estimated at 4,000,000 square miles. It penetrates northern Europe by the White Sea and Sea of Kara, and northern Asia by the Gulf of Obi and a few small inlets, and northward from these shores seems interrupted by comparatively few islands. The northern shores of America, however, present so many islands and ice-locked inlets, that it has, up to the present moment, been impossible to determine whether land or water continues northward and surrounds the pole. The Antarctic Ocean, on the other hand, is open on all sides to the Pacific, Atlantic, and Indian Oceans, which thus insensibly merge themselves into the great Southern Ocean. So far as navigators have ventured to approach the southern pole, various islands and shores have been observed which would favour the idea of a circumpolar continent; but whether land, sea, or an ice-bound archipelago occupies the immediate region of the pole, is likely long to remain an undetermined problem. Altogether, the Antarctic is a cold, boisterous, and unapproachable ocean — its ice extending 10° nearer the equator than that of the Arctic, and offering few of those inducements that have stimulated repeated research in the Northern Ocean.

109. Such are the areas occupied by the waters of the ocean— areas and subdivisions which are not only necessary to intelligible description, but which are marked in reality by different conditions and characteristics in nature. Position on the globe decides their temperature; area and configuration determine their tides and currents; and the sum of these physical conditions regulates the nature and distribution of their plants and animals. Any change, therefore, either in position, area, or configuration, would be attended by a corresponding change of conditions, and any such alteration would affect all the consequences, physical and vital, that depend on external conditions. As they exist, the North and South Atlantic, situated under different latitudes, enjoy different temperatures; while the north, by virtue of its greater irregularity of form, and numerous ramifications into the land, exhibits a much more varied display of vegetable and animal life. The same also holds good of the North and South Pacific, with these important modifications, that the North Pacific, compared with the North Atlantic, is almost excluded from Arctic influences, while the numerous islands of the South Pacific occasion conditions, physical and vital, peculiarly its own. The Indian Ocean, surrounded on three sides by land, and situated, for the most part, in the torrid zone, presents peculiarities

unknown in other subdivisions; while the Arctic and Antarctic, receiving the minimum of solar heat, are ice-locked for the greater part of the year, and have little in common with the other sections of the ocean. As already stated, it is on these primary relations of position and configuration that the different temperatures, tides and currents of the various oceanic subdivisions depend; and it is entirely owing to these conditions that the specific life of one sea or ocean differs from the life of all other seas and oceans. And yet it must be borne in mind that, though diversely situated and characterised, there is still the most intimate connection and interchange between their waters—the colder ever flowing towards the warmer, and the warmer towards the colder, so that in this respect they constitute in reality one great and indivisible "world of waters."

Composition, Density, Pressure, Depth, &c.

110. This great ocean, in all its areas and ramifications, is characterised by a greater or less degree of *saltness*—this saltness arising from the presence of certain substances held in chemical solution in its waters. These substances are chloride of sodium (common salt), and sulphates of magnesia and lime, together with minor and varying proportions of salts of potash and ammonia, iodides and bromides of sodium, carbonate of lime, silica, &c.—amounting in all from 3½ to 4½ grains to the hundred of water. According to M. Regnault, the following is the mean of several analyses of sea-water:—

Water,		96.470
Saline Ingredients, 3.505.	Chloride of sodium,	2.700
	Chloride of magnesium,	.360
	Chloride of potassium,	.070
	Sulphate of lime,	.140
	Sulphate of magnesia,	.230
	Carbonate of lime,	.003
	Bromide of magnesium,	.002
Loss (including iodides, silica, &c.),		.025
		100.000

The preceding ingredients may vary in different seas, and according to the locality whence, and the season when, the water is taken, but only to the extent of a fractional percentage—the incessant circulation and intermingling of the ocean's waters by waves, tides, and currents, producing a uniformity, or all but uniformity, in its saline composition. It has been found, however, that the waters of the Southern Ocean are slightly salter than those of the Northern; that the greatest saltness takes place along the parallels of 22° north and 17° south, or in the courses of the trade-winds, which absorb and carry off an excess of evaporation towards the equator, where it descends in freshening rain-falls; and that from these limits of maximum saltness there is a slight progressive diminution towards either pole.

[In the southern hemisphere, says Captain Maury, there is more sea and less land than in the northern. But the hydrometer indicates that the water in the seas of the former is salter and heavier than the water of seas cis-equatorial; and man's reasoning faculties suggest, in explanation of this, that this difference of saltness, or specific gravity, is owing to the excess of evaporation in the southern half, excess of precipitation in the northern half, of our planet. "When water passes, at 212° Fahr., into steam, it absorbs 1000° of heat, which becomes insensible to the thermometer, or latent; and, conversely, when steam is condensed into water, it gives out 1000° of latent heat, which thus becomes free, and affects both the thermometer and the senses. Hence steam of 212° Fahr. will, in condensing, heat five and a half times its own weight of water from the freezing to the boiling point."—*M'Culloch.* Now there is in the southern a very much larger water-surface exposed to the sun than there is in the northern hemisphere, and this excess of heat is employed in lifting up vapour (and rendering salter) that broad surface, in transporting it across the torrid zone, and conveying it to extra-tropical northern latitudes, where the vapour is condensed to replenish our fountains, and where this southern heat is set free to mitigate the severity of northern climates.]

111. Though communicating freely (by currents and counter-currents) with the ocean, the majority of inland seas are less salt than the ocean, in consequence of the influx of rivers into their circumscribed areas; but some, like the Red Sea, receiving no rivers, and subjected to active evaporation, have their saltness slightly in excess. As a general rule, inland seas receiving numerous rivers, and from their situation subjected to little evaporation, will be fresher than the ocean (*e.g.*, the Baltic); while others also receiving rivers, but subjected to a more active evaporation (as the Mediterranean), will have their saltness somewhat in excess. Though the saltness of the sea be pretty uniform at great depths, still at the surface, owing to the admixture of rain, river, and iceberg water, it is not quite so salt; and this freshness will increase, of course, according to proximity to the mouths of the entering rivers. It has also been ascertained that water from the surface contains less air than that from depths, and the difference may equal one-hundredth of the volume of water.

112. Another noticeable property of salt water is, that it is less sensitive, if we may so speak, to cold than fresh water—the latter freezing, as is well known, at 32°, while sea-water is not converted into ice till the thermometer sinks to 28½° Fahr. It is likewise less vaporisable than fresh water—that is, a given extent of salt-water surface gives off less vapour during the same time, and under the same conditions, than an equal extent of fresh-water surface. Such composition and properties are no doubt all-essential in the economy of nature. Shell-fish, crustacea, coral-zoophytes, and other creatures, derive the calcareous matter of their structures from the salts of the ocean; fishes breathe the aërated waters of the sheltered and undisturbed depths; and both plants and animals obtain conditions of existence which absolutely pure water would fail to supply. By its lower freezing-point a larger amount of surface is ever kept open and accessible; and by its slower evaporation a less amount of moisture is borne from its greater expanse to the comparatively smaller surface of the land. As sea-water freezes (the ice being fresh) the surface portions become salter and salter, and then, through their greater specific gravity, sink downward, while the lighter and warmer portions arise to supply their place—a circulation which at once limits the surface-cold and maintains the equilibrium of density.

113. It will be seen that no notice has been taken in the preceding paragraphs of ingredients—sand, mud, and organic debris—that may be *mechanically suspended* in the waters of the ocean. These are purely local and accidental, depending on river-floods, tidal-currents, waves, storms, and other commotions. When the commotion subsides, the waters regain their transparency; and altogether, unless along wasting shores, in tidal estuaries and river embouchures, there is really very little matter mechanically suspended in the waters of the ocean. On the other hand, the ingredients held in *chemical solution* are all but constant and universal. The water that evaporates from the ocean is all but absolutely pure; it falls on the land in mist and rain and snow; percolates the soil and rocks; and returns again to the ocean, carrying with it the saline substances it has dissolved from the rocky strata. The ocean is thus the great equalised repository of all that is borne from the continents; and there they would accumulate, were it not for the beautiful counterpoise that is ever kept up by the requirements of plants and animals, as well as by the intervention of new chemical arrangements among its multifarious sediments. So far as Geology can determine by a study of the marine life (shell-fish, corals, foraminifera, &c.) of former ages, the composition of the ocean seems to have been much the same as it is now; and thus, in all our reasonings, we may regard its saline contents as having long arrived at a state of equilibrium and fixity. Even if there were a slight excess at any one period, that excess would be merely temporary, as those incessant mutations of sea and land, involving the formation of new limestones, magnesian

limestones, rock-salts, and the like, are ever taking up the surplus, and restoring the equilibrium.

114. *The mean specific gravity of sea-water*, as compared with absolutely pure water at 62° Fahr., is found to be 1.0275—an amount that corresponds to a percentage of 3.505 of saline ingredients. The salter, therefore, that water is, the greater its gravity; and hence the fresh water of rivers, of melting icebergs, &c., will float for many miles on the surface of the sea before the two fluids be thoroughly diffused and commingled. It is owing to this that potable water has been *skimmed* from the surface several miles from the mouths of large and rapid rivers; and it is also for this reason of unequal densities that currents are established in different parts of the ocean—the heavier ever seeking to establish its equilibrium. As already mentioned, water acquires its minimum volume, or greatest density, at a temperature of 40°, and becomes lighter and lighter either as it rises above or falls below this temperature. Owing to this property a perpetual interchange or circulation is kept up among the waters of the ocean, *horizontally* from colder to warmer, and from warmer to colder regions; and *vertically* from surface to depths, and from depths to surface.

115. Again, water being slightly compressible, it follows that at great depths in the ocean the water will be denser than at the surface, and consequently what takes place near the shore will be impossible at extreme depths. According to experiment, water at the depth of 1000 feet is compressed $\frac{1}{340}$th of its bulk; and at this ratio the pressure at the depth of one mile would be equivalent to 160 atmospheres, or 2320 lb. on the square inch; while at the depth of 4000 fathoms, or about $4\frac{1}{2}$ miles, it would amount to 750 atmospheres! It is owing to this enormous pressure that corked bottles sunk to great depths have their corks always forced in; and that pieces of oak-wood carried down to similar depths have their fibres and pores so compressed as to be afterwards incapable of floating on the surface. At vast depths, therefore, it is generally supposed that vegetable and animal life, as known to us, could not possibly exist; and though some recent soundings in the north seas at the depth of 1260 fathoms would seem to oppose this opinion, yet the paucity and uncertainty of these trials leave the question still in doubt; and we may, in the mean time, adhere to the general belief that the extreme depressions of the ocean, like the extreme elevations of the land, are barren and lifeless solitudes.

116. Touching the *depth of the ocean*, it has been already observed, that as the dry land rises variously and irregularly above the level of the ocean, so the bottom of the ocean sinks variously

and irregularly beneath its waters. All that has been learned from the soundings of navigators establishes the fact, that there are shallow shoals and banks, deeper flats and plateaux, and still deeper troughs and valleys; and that were the whole laid dry, we should have presented to us much the same kind of inequalities as are presented by the surface of the land. Indeed, when situated on a lofty mountain and looking down on the hills and valleys below, we see before us much the same irregularity of surface as that which must lie beneath the waters of the ocean. The sea-bed is but the submerged surface of former lands, and, unless perhaps in the instance of coral-reefs and submarine volcanoes, there is no foundation for the belief that the troughs and precipices of the ocean are sharper and more abrupt than those of the dry land. If the inequalities of the land are worn and rounded by meteoric agency, and masked by a covering of soil, so the inequalities of the ocean-bed were worn down before submergence, and have since been masked, except in the courses of tides and currents, by a still deeper covering of sediment and drifted debris.

117. As a general rule, it may be stated that, where the land slopes gradually towards the ocean, the waters also deepen gradually; and, on the other hand, where the land descends abruptly, the sea deepens, in like manner, suddenly and abruptly. In fact, this is only the natural consequence of slope and counter-slope, and a great relation to which there is scarcely an exception. The northern plains of Russia and Siberia, for example, slope gradually into the shallow bed of the Arctic Sea, just as the abrupt terminations of South America, Africa, and Australia dip suddenly into the deeper waters of the Southern Ocean. The level plains of China spread gently outwards into the shallow waters of the Yellow Sea; the low shores of eastern England, in like manner, slope slowly into the comparatively shallow basin of the North Sea; while, on the other hand, the precipitous coasts of Norway dip suddenly down into a corresponding depth of water. This fact, that low lands are generally bordered by shallow seas and high lands by deeper water, affords no idea, however, of the depths of distant and central expanses, and for these we must either appeal to theoretical deduction or to actual observation.

118. So far as experiment is concerned, comparatively little is known of the absolute depth of the ocean; and even where deep soundings have been made, there has been great liability to error, partly from the imperfection of the apparatus employed, and partly from the chance of the line being deflected from the perpendicular by the force of under-currents. The common notion that the extreme depths of the sea correspond to the extreme

heights of the land—that is, as the highest mountains rise little above five miles, so the greatest depths sink little below that amount—has no foundation in fact, there being no necessary connection between the two phenomena. The *mean elevation* of all the land—continents and islands, mountains and plains—has been estimated by Humboldt at somewhat less than 1000 feet; and the *mean depth* of the ocean has been calculated by Laplace, from tidal waves and kindred phenomena, to be at least 21,000 feet, or about four English miles. We know, however, that a very large proportion of the ocean is comparatively shallow, and not a tithe of this depth; and therefore, to make up the mean, some other portions must be proportionally deeper, and to the extent, it may be, of eight or ten miles. Indeed, soundings (no doubt open to question) have been made in the South Atlantic, both by British and American navigators, varying from 27,000 to 46,000 feet; and soundings perfectly reliable have been taken in the North Atlantic, off the bank of Newfoundland, to the depth of 25,000 feet; while from calculations on the velocity of tidal waves, which are found to proceed according to the depth of the channel, it has been estimated that the extreme depths of the same ocean are about 50,000 feet, or more than nine miles.

119. Regarding the water in the ocean as a constant quantity, it must follow that the shallower the sea-bed the more expansive its area; and *vice versâ*, the deeper the trough the more circumscribed the area of the waters. Altogether, and according to our present information, we may admit a mean depth of four miles for the ocean, and reliable soundings to the extent of five miles; but believe, partly on experiment, and partly on theoretical grounds, that several portions sink to the depth of eight or ten miles. It may also be stated in general terms that the Atlantic, averaging from three to five miles, is, on the whole, deeper than the Pacific, and yet the great "Telegraphic Plateau" stretching from Cape Clear to Cape Race, a distance of 1640 miles, is only about 11,000 or 12,000 feet in depth; that great depths (from four to six miles) have been determined in the Indian and Southern Oceans; that the Antarctic becomes shallower as we approach the pole; and that the Arctic, of moderate depth, is characterised by great irregularity and diversity. With regard to the minor seas, the greatest ascertained depth in the Mediterranean is about 13,000 feet; in the Red Sea, 6300 feet; in the Baltic, 840 feet; in the Caribbean Sea, 14,000 feet; and in the Gulf of Mexico, about 8000 feet.

Temperature, Colour, Luminosity, &c.

120. Respecting the *temperature of the ocean*, few reliable or sufficiently extended observations have yet been made, either as regards its various areas or its successive depths. We know, however, that it is more equable than that of the land, and that, though the superficial portions are colder in summer than the surrounding atmosphere of any contiguous terrestrial district, they are in winter always several degrees higher—thus exercising the function of a great storehouse of heat for modifying and equalising the climates of the adjacent land. The surface temperature is necessarily highest along the equator, or rather along a belt, varying from 2° to 8°, on either side of the equator, and then gradually diminishes as we approach either pole, but on the whole more rapidly in the southern than in the northern hemisphere. Along this equatorial zone temperatures have been found ranging from 78° to 85°—higher exceptional temperatures (87° and 88°) having occasionally been taken in parts of the Indian Ocean and the Gulf of Mexico. Though varying in *surface temperature* according to latitude—from 80° at the equator to perpetual ice towards either pole—it has yet been found that at very great depths the ocean preserves a uniform *mean temperature* of about 39½°. Thus, according to the experiments of Sir John Ross, the circle of the mean temperature of the ocean in the southern hemisphere lies between the 56th and 59th parallels of latitude; along which belt the uniform temperature of 39½° has been found to prevail at all depths, from the surface downwards. To the south of this line, owing to the absence of solar heat, the surface depths are colder, and the mean of 39½° is not reached in the 70th parallel till we descend to the depth of 4500 feet, beneath which to the greatest depths the temperature is uniformly at 39½°, while the surface temperature is only 30°. To the north of the line of mean temperature, in consequence of the absorption of the sun's heat, the surface-depths are warmer; and in the 45th parallel the mean of 39½° is not reached till we descend 3600 feet; while at the equator we have to descend 7200 feet before the same mean is obtained, and then at all depths below this it maintains the unvarying mean temperature of 39½°, though the surface is at 80°. Presuming that a similar order prevails in the northern hemisphere, we have thus three great regions of oceanic temperature—an equatorial and two polar, the former characterised by warm water at the surface, and the latter by cold.

121. Such are the facts, so far as ascertained, respecting the general temperature of the ocean; but inland seas and currents may be

colder or warmer according to the position they occupy and the direction from whence they proceed. The surface temperature of the Gulf of Mexico, for example, is several degrees warmer (86° and 88° have been named) than the main Atlantic under the same latitude; the waters of the Gulf Stream are also several degrees higher in a large portion of its course than those through which it flows; while the Arctic Current, on the other hand, is considerably colder. "It may be regarded as a general rule," says a high authority, "that the temperature of all inland seas, at great depths, represents nearly the mean temperature of the earth in the latitudes where they are situated; whilst in the ocean, the low temperature at the bottom, in every latitude, is produced by the cold currents setting eternally from the polar regions, and which maintain the water at an almost constant temperature—that of its maximum density, 39° Fahr."

122. Besides the preceding conditions of saltness, density, depth, and temperature, there are also those of *colour* and *luminosity*, usually adverted to by navigators and geographers. In small quantities water is generally regarded as colourless, but that of the ocean assumes different hues, and this altogether independent of the colours of the sky which may be mirrored on its surface. Thus, in the open ocean, shallow water is indicated by a *green tint* of different degrees, while profound depths are characterised by an *indigo blue*. Whether this arises from the greater density of the mass, or from some peculiarity of its saline constitution, is not yet satisfactorily known; but the fact remains, and "sea-green waves" and "dark-blue oceans" are something more than mere poetic fancies. Of course, in some localities there may be accidental or even permanent discolorations, arising from the entrance of river-water, from peculiarity of bottom, or from the presence of countless myriads of vegetable and animal organisms; hence the application of such terms as Red, Black, White, Yellow, Green, and Vermilion to certain seas and areas of the ocean. In general, however, the ocean water is clear and limpid, and, under favourable circumstances, objects are reported to have been seen at a depth of 300 and 400 feet, or about half the distance to which the sun's light is supposed to penetrate into the abyss of waters.

123. The phenomenon of luminosity or phosphorescence is less general, perhaps, and seems to depend in a great degree on locality, season of the year, and state of the weather. Luminous animalcules and creatures of various kinds appear to be the proximate cause of the phenomenon, which becomes more apparent in still, dark nights, and where the surface of the water is disturbed by the stroke of an oar, or the friction of a passing keel.

NOTE, RECAPITULATORY AND EXPLANATORY.

In the preceding chapter attention has been directed to the main natural divisions of the ocean ; and to the composition, density, depth, temperature, colour, luminosity, and other physical characteristics of their waters. The divisions of the ocean into Pacific, Atlantic, Indian, Arctic, and Antarctic areas, are sufficient for the ordinary purposes of description ; and the nomenclature of their various ramifications after some discoverer, position, adjacent country, colour, or other peculiarity, has been long established in general geography. Their further subdivision into *zones*, *belts*, *regions*, and the like, comes under the consideration of Climatology rather than of Hydrography ; and the technicalities (bays, gulfs, straits, creeks, &c.) by which their minor sections are distinguished, have been already noticed in par. 42. Their dimensions are matters merely of measurement and calculation ; their composition, depth, temperature, and the like, are subjects for experiment and observation.

Occupying different positions on the earth's surface, and having different configurations, the oceans and seas, properly so called, are necessarily characterised by different physical and vital conditions. The Pacific, almost shut out from the influences of the Arctic Ocean, is in a different condition from the Atlantic, which communicates freely with the north ; while the Indian Ocean, encircled on three sides by land, and lying largely in the torrid zone, presents external conditions differing widely from either. All three open broadly to the great Southern Ocean, from which they receive the primary impulse of their tides and currents ; but while the Indian and Atlantic are deep and free, the Pacific is largely obstructed by reefs and islands. It should also be borne in mind that the main oceans, like the great continents, lie meridionally, or at right angles to the equator, and are thus prevented, by the intervention of the land, from receiving in their winds, tides, and currents, the normal effect of the earth's daily rotation.

Though differing slightly in different areas, the composition of sea-water is, on the whole, very equable, and 3½ per cent of saline ingredients may be set down as the general average. Along the courses of the trade-winds, in circumscribed seas, and other similar areas subjected to active evaporation, this percentage may be slightly increased ; while in others it may be correspondingly decreased by periodical rainfalls, by the melting of polar ice, or by the influx of large and rapid rivers. The average density of sea-water, as compared with pure water at 62° Fahr., is 1.0275; and this density, corresponding as it does with an average saltness of $3\frac{1}{2}$ per cent, will decrease where the water is fresher and increase where it becomes salter than the general average. This saltness and density renders the ocean less vaporisable than fresh water, and also keeps it longer from freezing—the freezing point of fresh water being 32° Fahr., while that of sea-water is $28\frac{1}{2}$°. This composition is all-essential to the wants of its plants and animals; and though the rivers are incessantly carrying in fresh accessions of saline matter, the equilibrium is ever maintained by these wants as well as by the chemical interchanges that take place among its sediments.

The average depth of the ocean is estimated at 4 miles, and reliable soundings have been taken at nearly 5 miles; but, as a large portion is much under the general average, it is highly probable that some of its recesses may sink to the depth of 8 or 10 miles. So far as we know, the ocean-bed has its deeps and shoals, its pits and precipices, its troughs and ridges, very much like the surface of the dry land. In fact, it is but the submerged surface of former lands; and no better conception can be formed of its irregularities than by standing on some lofty mountain, and supposing the hills and valleys, the glens and gorges, the plains and plateaux that lie beneath, to be covered with water. A knowledge of these depths—or rather of the shoals and irregularities of the ocean-bed—is of vast importance in geography, at the same time that it is all-essential to navigation. The safety of the commerce of the civilised world depends upon correct chartography; these deeps and shallows determine the direction of currents, and inset and velocity of tides; and marine life is visibly regulated both in its dispersion and numerical amount by depth and mineral conditions of sea-bottom.

The surface temperature of the ocean varies of course with the latitude, being highest at the equator, and gradually decreasing towards either pole. In the torrid zone temperatures varying from 78° to 88° have been noted, and from these maxima it declines, stage by stage, to the perpetual ice of the polar regions. The mean temperature has been ascertained to be $39\frac{1}{2}$° Fahr., or nearly that of water at its maximum density; and between the 56th and 57th parallels (S. lat.) this temperature has been found to be uniform from the surface to the greatest depths. Towards the poles, however, the surface becomes colder, and the mean of $39\frac{1}{2}$° in the 70th parallel is not found till at the depth of 750 fathoms; while towards the equator the surface grows warmer, and the mean of $39\frac{1}{2}$° is not reached till at the depth of 1200 fathoms.

Colour, luminosity, and the like, are generally local and seasonal peculiarities—depending upon the presence of mineral or organic impurities which may occur in one area and not in another, or during one brief season, and yet be absent for the greater portion of the year.

To those who desire more extensive details of the ocean and its physical peculiarities, we cannot recommend them to a more instructive or attractive source of information than Captain Maury's 'Physical Geography of the Sea'—a volume replete with reasonings as well as observation, though occasionally impeded by reflections which impair, rather than impart to, the value of its information.

IX.

THE WATER—ITS OCEANS AND OCEAN-CURRENTS.

Waves—their Height, Velocity, and Impact.

124. LIKE other fluids whose particles are free to yield to every impulse, the waters of the ocean are subject to several movements, the more important of which are waves, tides, and currents. Waves are produced by winds, and occasionally by earthquake commotion; tides by the attractions of the moon and sun; and currents chiefly by that incessant tendency which waters of different densities and temperatures have to assume a state of equilibrium. And, first, of WAVES, whose main characteristics are magnitude, velocity, and force of impact. Waves occur in every part of the ocean, and wherever the wind blows,—the aërial current drifting the surface waters along with it, and producing undulations, which increase, according to the power of the propelling force, from the gentlest ripple to billows 30 or 40 feet in height. In deep and open seas a continuous wind produces merely an undulation or up-and-down movement of the surface waters; and this commotion, even in the case of a wave a quarter of a mile in breadth and 40 feet high, is not sensibly felt at a depth of 220 fathoms. But in obstructed and shallow seas the lower part of the advancing undulation is retarded by frictional contact with the bottom—the upper portion advances with headlong motion, and ultimately breaks with forcible impact on the opposing shore, which is worn and abraded by the backward and forward motion of the surf. Such is the beginning, course, and termination of ordinary waves,—at first a mere ripple; as the gale increases, a long roll and swell in the deep sea; and ultimately a cresting and dash of breakers on the shelving shore. Occasionally, however, the wind shifts, and sets in waves from opposite directions, and these crossing and commingling produce

a violent commotion, even far out at sea, and in the deepest waters.

125. The aspects and characters of waves are known to sailors by many different names; the ruffle or ripple under a rising breeze being spoken of as a *catspaw*, the long undulation as a *swell* or *billow*, the shorter undulations as they approach the shore as *rollers* and *breakers*, and the broken water along shore as *surf*. The big heavy waves that occasionally set in when there is no wind (having been produced by storms far out at sea), are said to form a *ground-swell;* the commotion produced by cross-waves forms a *chopping sea*, and in a less degree a *jabble* or *cross-lipper;* but these and similar terms belong more to nautical technicality than to the generalities of Physical Geography. In circumscribed and shallow seas waves are short and abrupt; in the open ocean they assume the character of a long rolling swell. Whatever diminishes the friction of the wind—packs of ice, floating sea-weed, oil, and the like—suppresses the rise of the waves; and even during fogs and rains the sea is not so rough as in dry weather, in consequence of the diminished attraction of the atmosphere for water, and necessarily lessened concomitant friction.

126. Generally speaking, the magnitude of *wind-waves* has been greatly exaggerated, partly from the difficulty of making correct observations, and partly from the impression of dread produced on the mind of the observer. The greatest waves known are said to be those off the Cape of Good Hope, where, under the influence of a north-west gale, they have been found to exceed 40 feet in height. Off Cape Horn they have been measured at 32 feet from trough to crest; and in the North Atlantic, waves from 20 to 25 feet are by no means uncommon. In our own seas, however, they rarely exceed 8 or 10 feet; and all accounts of their running "mountains high" must be received as mere poetical exaggerations. In the case of *earthquake-waves* the conditions are altogether different; and as the whole mass of water is then thrown into commotion by sudden and abrupt risings, fallings, and whirlings, waves, or rather walls of water, 60 or 80 feet high, may be thrown with tremendous impetus upon the land. In the Lisbon earthquake of 1755, the destructive wave that rolled in upon the coasts of Portugal was estimated at 60 feet; and in the Simoda (Japan) earthquake of 1854, three huge waves, at intervals of a few minutes, rushed into the bay, destroying the native craft, and completely submerging the town of Simoda.

127. The velocity of waves depends primarily, of course, upon the power and continuance of the wind, but is greatly modified by, and bears an ascertainable relation to, their magnitude and

the depth of the water over which they travel. Thus it has been calculated by Professor Airy that a wave 100 feet in breadth and in water 100 feet deep travels at the rate of about 15 miles per hour; one 1000 feet broad and in water 1000 feet deep, at the rate of 48 miles; whereas another, 10,000 feet in breadth and in water 10,000 feet deep, will sweep forward with a velocity of not less than 154 miles per hour. This relation between the breadth of a wave, its velocity of progress, and the depth of the water in which it travels, has been embodied by Mr Airy in the following table:—

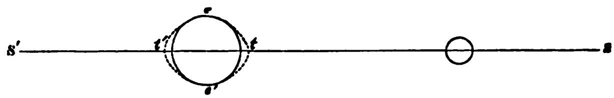
Depth of Water in Feet.	*Breadth of the Wave in Feet.*							
	1	10	100	1000	10,000	100,000	1,000,000	10,000,000
	Corresponding Velocity of Wave per Second in Feet.							
1	2.262	5.320	5.667	5.671	5.671	5.671	5.671	5.671
10	2.262	7.154	16.883	17.921	17.933	17.933	17.933	17.933
100	2.262	7.154	22.264	53.300	56.672	56.710	56.710	56.710
1,000	2.262	7.154	22.264	71.543	168.830	179.210	179.210	179.330
10,000	2.262	7.154	22.264	71.543	226.260	533.900	566.720	567.100
100,000	2.262	7.154	22.264	71.543	226.260	715.430	1688.300	1793.300

128. The force with which a wave strikes against any opposing barrier depends, in like manner, upon its bulk and velocity; and in the case of huge waves this impact is enormous. From experiments made at lighthouses and breakwaters, their effective pressure has been estimated as high as 6000 lb. per square foot: and one has only to observe the breaches occasionally made in sea-walls, and the distance to which blocks of stone, several tons in weight, have been hurled forward, to be convinced of their great propulsive power. Of course the force with which a wave simply *strikes* is not to be altogether estimated by its propulsive power, for substances submerged in water lose a certain portion of their weight, which greatly facilitates their displacement and transport.

Tides—their Origin and Influence.

129. The next, and perhaps the most important and persistent of oceanic movements, is that of the TIDES—a term applied to the periodic rising and falling of the waters, occasioned chiefly by the attraction of the moon, but partly also by that of the sun. In obedience to the universal law that "every particle in nature attracts every other particle with a force inversely as the square of the distance," the earth is attracted by the sun and moon, but more by the latter, in proportion to its greater proximity. Land

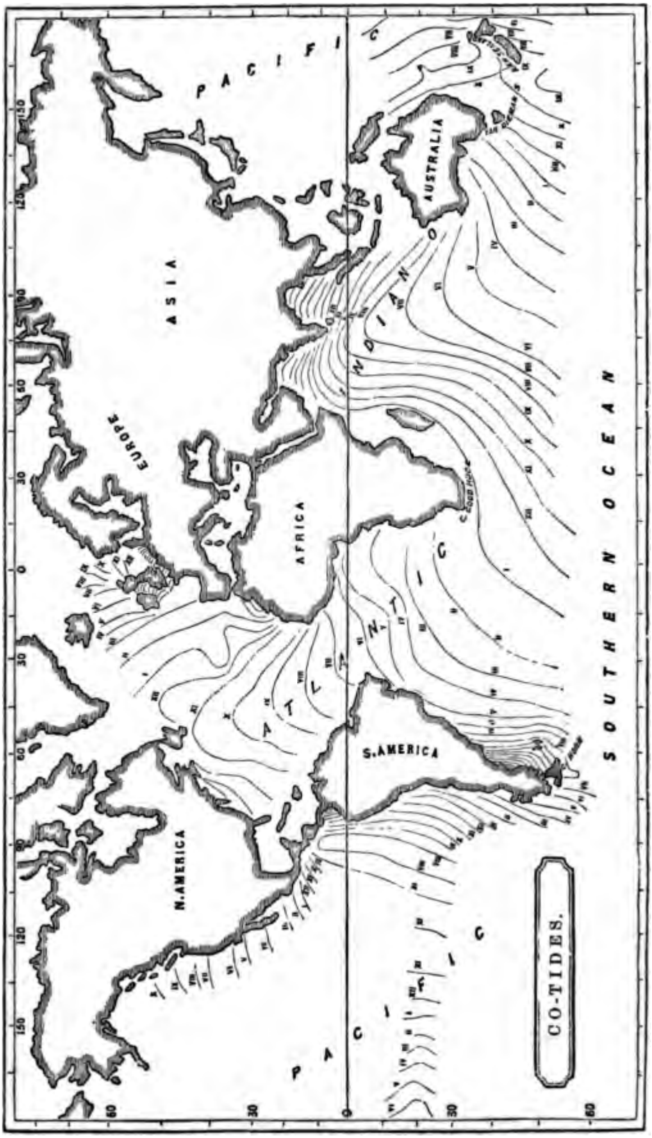
and water alike experience this attraction, but the particles of the latter being free to move among themselves, the mass of the ocean is drawn out beyond its normal circumference towards the attracting bodies. Had the earth been immovable as regards the sun and moon, this bulging out of the waters would have been stationary; but as she turns on her axis, meridian after meridian is brought directly opposite to the attracting force, and thus the rising of the waters becomes a great *tidal wave* or *flow* that travels round the globe. The moon, we have said, exercises the greater attraction (her attraction being to that of the sun as 100 to 38), but when the sun and moon are in conjunction, or in opposition (that is, at new and full moon), the sum of the two attractions will cause the greatest possible rise, known as *spring-tides;* and when the moon is in her quadratures (that is, at her first and last quarters), the sun's attraction, acting in a different direction, will diminish the lunar tide, and then we will have the least rise, or *neap-tides.* The following diagram may assist the comprehension of these phenomena:—



Here *t* being the nearest point of the earth's surface to the moon, the waters at that part are most attracted towards that luminary, and of course rise highest; while on the opposite side at *t'* the earth is drawn, as it were, away from them, and they stand out nearly at the same height as those at *t*. But as the waters rise simultaneously at *t t'* they are drawn away from *e e'*, and as the earth turns round, each point on its surface will necessarily have two high-waters and two low-waters per day. In other words, the sea *flows* or rises as often as the moon in her apparent circuit passes the meridian, both the arc above and the arc below the horizon, and *ebbs* or falls as often as she passes the horizon, east and west. The solar day, however, being only 24 hours, and the lunar (owing to the moon's monthly course round the earth) being 24 hours, 54 minutes, it requires rather more than a rotation of the earth to bring the same meridian to the same position, relatively to the moon, as it had the preceding day. In other words, it requires more than 24 hours to bring the moon round to its vertical position over any given place, and thus the tides of one day are always about an hour later than they were on the preceding day. Again, had the moon been the sole attracting body, the tides would have risen always to the same height; but the sun, exerting a simultaneous attraction either along with or against that of the moon, creates an alternate maximum and minimum of flow. Thus, when the sun is at S and S′ his attraction is combined with that of the moon, and a higher tide is the result. When at S the darkened side of the moon will necessarily be towards the earth, and it is new moon; and when at S′ the illuminated face of the moon will be towards the earth, and it is full moon; so that the higher or *spring-tides* take place alternately at new and full moon. On the other hand, when the moon is 90° from the sun's place (that is, when she is in her first and last quarters, or half moon), his attraction, being exerted at right angles, counteracts that of the moon, and the result is the lower or *neap-tides*—the proportion of spring to neap being as 138 to 62, or nearly as 7 to 3. The *height* and *time* of the tides thus vary with the moon's age; and this being known, their recurrence and culmination at any given spot can be calculated with the greatest exactitude. The greatest tides occur, of course, when the luminaries are nearest and pass most vertically to the place of observation; and as each tide has only about six hours to *flow* and about six hours to *ebb*, the highest must necessarily be the *swiftest*, and the lowest the *slowest*.

130. Such, in general terms, is the theory of the tides; and had the surface of the globe been entirely covered with water, the tidal wave would have been regular and continuous from meridian to meridian, and, as a consequence, highest in the region of the equator, and gradually falling away towards either pole. But the continuity of the ocean being interrupted by land, and this land lying in a great measure meridionally, as well as being irregular in outline, and consisting in many parts of islands, the course of the tidal flow is obstructed, and deflected into various courses. Under the present arrangement of sea and land, these courses are, however, sufficiently persistent; and thus their directions, times, velocities, and heights, can be determined with accuracy for the purposes of navigation. The Southern Ocean, encircling the globe, and being comparatively uninterrupted by land, may be regarded as the area in which the tidal wave receives its great primary impulse. It is thence carried forward, deflecting itself northward into the Indian, Atlantic, and Pacific Oceans, where, uniting with the minor tide-waves generated in these expanses, it flows, rises, and subdivides, according to the outline of the coasts, the depth of water, and the obstruction of islands.

131. Notwithstanding the complications arising from these causes, there is still great regularity in the bi-diurnal flow and ebb


CO-TIDES.
PACIFIC
ASIA
EUROPE
AFRICA
AUSTRALIA
INDIAN OCEAN
ATLANTIC
N.AMERICA
S.AMERICA
SOUTHERN OCEAN
C. GOOD HOPE

of the tides; and by noting the times at which the same high-water reaches different parts of the coast, a series of lines connecting these points may be laid down so as to indicate the course of the tidal wave with great precision. Such a series of lines are termed *co-tidal lines*, or lines of simultaneous tide, and mark the progress of the summit of high-water from its origin in the Southern Ocean to its remotest ramifications in northern waters. We say northern waters, for though the primary and normal direction of the tidal wave is from east to west, in obedience to the apparent course of the sun and moon, yet, on entering the troughs of the Indian and Atlantic Oceans, it is compelled to assume a northerly course in accordance with the configuration of these seas. Thus the new or full moon high-water that passes Van Diemen's Land every morning at twelve, takes twelve hours to reach Ceylon, and thirteen to reach the Cape of Good Hope; in another twelve hours it has passed up the Atlantic, and arrived at Newfoundland; at the end of the third twelve it has rounded the north of Scotland, and is opposite to Aberdeen; at the fourth twelve, or at midnight of the second day, it is opposite the mouth of the Thames; and it is "not till the morning of the third day that this wave fills the channel of the Thames, and wafts the merchandise of the world to the quays of the port of London." (See Map of *Co-tidal Lines*.)

132. The tides, we have said, may be regarded as taking their rise in the uninterrupted expanse of the Southern Ocean. As the wave proceeds westward, it is deflected northward broadly into the Indian Ocean, rapidly and deeply into the larger channel of the Atlantic, and slowly and feebly into the Pacific, where its course is obstructed by numerous islands and coral-reefs. The *velocity of the tidal wave* depends primarily on the conformation and depth of the ocean—proceeding with the greatest rapidity where the ocean is freest and deepest. As the co-tidal lines are laid down at hourly distances, they afford a pretty correct estimate of the tidal velocity—the wider the lines (that is, the greater the distance travelled over in one hour) the greater the speed, and the closer the lines the slower the rate of progress. In the free depths of the Southern Ocean this velocity may equal 1000 miles per hour, while in restricted seas like the North Sea the rate is scarcely a twentieth of that amount. As the tidal wave differs from a wind-wave in not being a mere undulation, but a wave of translation, its *height* in any sea will depend mainly on the configuration of the shore, the form of bottom, and the direction in which it is propelled. In the open expanse of the Southern Ocean the tidal wave rarely exceeds five or six feet, and in the Indian and Atlantic Oceans perhaps eight or ten; but in bays and gulfs opening

broadly to its course, and narrowing towards their interior recesses (such as the Bay of Bengal, our own Bristol Channel, and the American Bay of Fundy), it may rise to 20, 30, or, under favourable circumstances, even to 50 or 60 feet in height. And where such seas terminate in river-estuaries, the wave, still converging, forms a high head or wall of water, termed a *Bore*, which ascends the river with sudden and destructive impetuosity. Such are the tidal bores of the Tsien-tang, which are said to extend across the river 30 feet high, and ascend with a velocity of 25 miles per hour, of the Hooghly 20 and 25 feet high, of the Garonne 10 and 12 feet, the Severn 9 feet, the Amazon 12 and 13 feet, and other rivers whose gradually narrowing estuaries are exposed to the concentrated incidence of the tidal wave. On the other hand, inland seas and gulfs whose openings are narrow, and lie transversely to the course of the tidal wave (as the Mediterranean and Baltic), experience little or no rise, and are next to tideless. Not only is the primary wave that sets up the Atlantic excluded from such seas, but their own areas are too limited to admit of the formation of any perceptible tide-wave of their own; and thus, for all practical purposes, strictly inland seas and lakes may be considered as tideless.

133. Unlike an ordinary wind-wave, whose undulations are imperceptible at the depth of 1000 or 1200 feet, and unable to disturb from its repose the smallest grain of sand, the progressive motion of the tide-wave affects the whole mass of waters from the surface down to their greatest depths. The mechanical effects of the wind-waves are felt chiefly along the shore-line in their battering, wearing, and abrading action; the tide-waves, on the other hand, act more like currents, which, in their ebb and flow, are ever transferring, arranging, and re-assorting the sediments of the ocean. The wind-wave merely breaks upon the bars of rivers and renders their navigation dangerous; the tidal wave, by its influx, fills the river-channel and renders it navigable, and by its efflux, scours out impurities, and carries them forward into the general reservoir of the ocean. The wind-wave may be stilled, and the surface of the ocean be as smooth as a mirror; while it is driven from one coast it impinges on another; or the wave from one direction may counteract that from another: but the ebb and flow of the tidal wave is regular and incessant, and in its direction, time, height, velocity, and power, will continue the same while sea and land remain undisturbed in their present relations.

Currents—their Causes and Functions.

134. We now proceed to what are termed the CURRENTS of the ocean—movements which, like great rivers, are ever transferring the waters from one region to another. They form, in fact, the circulatory medium by which the ocean is maintained in a state of equilibrium, and depend primarily upon the unequal temperatures and densities of different zones of the ocean and the unequal evaporation sustained by these zones; and secondarily upon the rotation of the earth, which modifies the directions imparted by these primary causes. Wherever we have waters of different temperatures, or, what is the same thing, of different densities, there the lighter will ascend and the heavier descend; and wherever a deficiency takes place through evaporation, there the waters will flow in from the adjacent parts to make up the deficiency. But difference of density may also arise from different degrees of saltness, and wherever the salter water subsides and flows off as an under-current to some fresher region, there at the same time will the fresher and lighter flow in from above to restore the equilibrium. Understanding these facts, and bearing in mind that the continuity of the ocean is interrupted by continents and islands, reefs and shoals, and further disturbed by winds and tides, it will readily be seen why its currents should assume different characters and courses. In fact, the currents and counter-currents of the ocean are extremely complicated; and though the courses and causes of some of the main streams are intelligible enough, there remains very much to be done in this department of Hydrography.

[On the equilibrium or equalisation of the waters of the ocean in temperature, density, saltness, &c., it has been appropriately remarked by Captain Maury, that "water, while its capacities for heat are scarcely exceeded by those of any other substance, is one of the most complete of non-conductors. Heat does not permeate water as it does iron, for instance, or other good conductors. Heat the top of an iron plate, and the bottom becomes warm; but heat the top of a sheet of water, as in a pool or basin, and that at the bottom remains cool. The heat passes through iron by conduction, but to get through water it requires to be conveyed by a motion, which in fluids we call *currents*. Therefore the study of the climates of the sea involves a knowledge of its currents, both cold and warm. They are the channels through which the harmonies of old ocean are preserved. Hence, in studying the system of oceanic circulation, we set out with the very simple assumption—*that from whatever part of the ocean a current is found to run, to the same part a current of equal volume is bound to return; for upon this principle is based the whole system of currents and counter-currents of the air as well as of the water.*"]

135. It is usual to arrange the ascertained currents into *con-*

stant, *periodical*, and *variable*—the constant being those arising from the combined influences of unequal temperatures and densities in the waters of the ocean, the rotation of the earth, and the trade-winds; the periodical by the tides, the monsoons, and the sea and land breezes in tropical countries; and the variable, such as may be produced by local peculiarities in the tides and winds, the melting of ice in polar regions, and other similar causes. It is also customary to speak of *drift currents* and *deep-sea currents*—the former due to the long-continued agency of the wind, and only affecting the waters to a trifling depth, the latter arising from the great primary causes of temperature and density above alluded to, and extending their influence hundreds of fathoms beneath the surface. In like manner, it may be useful to note the distinction between a *marine*, or upper current, and a *submarine*, or under-current; between a *current* flowing one way, and a *counter-current* coming from an opposite direction; and between the mode of naming winds and water-currents—the former being named after the direction *from* which they blow, as a "west wind" (that is, one blowing from the west), and the latter after the direction *to* which they are flowing, as an "easterly current," that is, one flowing towards the east.

136. The constant and deep-sea currents being the more important, it is to these that we would mainly, and in the first place, direct attention. As already mentioned, the heat of the torrid zone, by warming the equatorial waters, renders them lighter, and occasions a greater evaporation there than in any other region; and as a consequence, the waters of the polar regions, being heavier, set in as an under-current towards the equator to restore the equilibrium. It must be noted, however, that the Atlantic and Pacific being land-locked, as it were, to the north, the principal exchange of cold and warm water takes place towards the Antarctic Ocean, into which both merge widely and without interruption. Here then we have two great primary currents setting in from north and south respectively; but as they proceed towards the equator they come stage by stage into latitudes where the earth's circumference rotates with greater velocity, and as they cannot at once partake of this increased momentum, they fall behind, as it were, and gradually assume a westerly course, in which their velocity is augmented by the influence of the trade-winds. They become, in fact, a combined equatorial current, where, growing warmer and warmer, they ascend to the surface, and are partly evaporated and partly flow over in warmer and lighter surface-currents northwards and southwards to either pole, again to become colder and again to find their way to the equator in incessant circulation.

From these four primary flows—the two from the poles towards the equator, and the two from the equator towards the poles—arises the great circulatory system of the ocean, which is modified and broken up into a number of minor currents by configuration of coast, form of bottom, unequal reception of heat by different areas, the influx of rivers, and other kindred causes. These various currents, having different directions, volumes, velocities, and temperatures, will be better understood, perhaps, by being arranged under the three great oceans—Atlantic, Indian, and Pacific—in which they respectively occur.

137. The principal and better-known currents of the Atlantic are the Equatorial, the Guiana, the Brazil, the Gulf Stream, the Guinea, and the Arctic. Besides these there are some minor drifts and branches, the courses of which will be better understood by reference to the Map (p. 140) than by any amount of description. The *Equatorial*, as the name implies, manifests itself chiefly in the region of the equator, and flows across the ocean from the African towards the American continent. When more than half-way across it shows a tendency to bifurcate into a north-west branch and a south-west branch, and this tendency increases till within 300 or 400 miles of Cape St Roque, when it fairly divides—sending one main stream northwards by the coasts of Guiana into the Caribbean Sea; and another, somewhat feebler, southwards along the shores of Brazil. The length of the Equatorial Current, from the coasts of Africa to the Caribbean Sea, is about 4000 miles; its breadth at its commencement 160, and where it divides 450 miles; its velocity is from 20 to 60 miles a-day; and its average temperature about 75° Fahr., or from 4° to 6° under that of the ocean through which it flows. Its southern, or *Brazil* branch, flows at a distance of about 250 miles from the coast (the intermediate space being occupied by variable currents), and at the rate of 25 miles per day; a rate, however, that is sensibly diminished by the cross stream from the Plata, and which gradually declines till the current ultimately dies away in the Strait of Magellan. The north-west branch of the Equatorial, spreading out as it proceeds and gradually diminishing in speed, ultimately merges into the drift of the north-east trade-winds; while the *Guiana* section proceeds unimpeded to make the circuit of the Caribbean Sea and the Gulf of Mexico.

138. As they make the circuit of the Caribbean Sea and the Gulf of Mexico, these western branches of the Equatorial Current acquire more heat, a greater degree of saltness, and that intense blue colour so characteristic of briny waters. With these new ac-


CURRENTS.
ARCTIC C.
DAVIS S. C.
GULF STREAM
SARGASSO SEA
EQUATORIAL C.
GUINEA C.
GUIANA C.
N.E. TRADE D.
MONSOON C.
COUNTER C.
ANTARCTIC C.

quisitions they leave the Mexican Gulf, and, pressing through the narrow channel of Florida, become the celebrated *Gulf Stream*—of all the Atlantic currents the most wonderful in its character and the most important in its results. Doubling the Cape of Florida, this Gulf Stream (that is, stream from the Gulf of Mexico) flows north-east in a line almost parallel to the American coast; touches the southern borders of the banks of Newfoundland; and thence, with increasing width and diffusion, proceeds across the Atlantic, till, in the region of the Azores, it spreads out into two great branches—one curving southwards towards the equator, and the other flowing northwards, impinging in its course against the western coasts of Europe, and ultimately losing itself in the waters of the Arctic Ocean. The length of this great ocean-river from its commencement to the Azores is 3000 miles, and its greatest breadth about 120 miles. When it leaves the Strait of Florida its velocity is about 4 miles an hour; off Cape Hatteras, in North Carolina, it is reduced to 3 miles; on the Newfoundland banks it is further reduced to 1½ miles; and this gradual abatement of force continues with its diffusion across the Atlantic. A similar decrease takes place in its temperature, the maximum of which in the Strait of Florida is 86°, or 9° above that of the ocean in the same latitude. Off Newfoundland, in winter, it is said to be from 25° to 30° above the water through which it flows; in mid-ocean, from 8° to 10°; nor is the heat wholly lost when it impinges against the shores of western Europe. The Gulf Stream is thus, in reality, a great thermal ocean-river, incessantly flowing from warmer to colder regions, diffusing warmth and moisture along its course, and tempering the climates of countries that lie within its influence. Compressed, as it were, at its commencement between two areas of colder water, its deep-blue warm current rises in convexity above the surrounding ocean; but as it proceeds it cools, becomes diffused, assumes the ordinary level, and partakes of the greener hue of northern waters. It sets a limit to the southward flow and chilling influences of the Arctic iceberg, that melts away in its warm stream, and becomes at the same time the great natural barrier between the Life of the Northern and Southern Atlantic.

139. The Equatorial Current, flowing westward from Africa to the Gulf of Mexico, and the Gulf Stream, flowing from that gulf eastward to the Azores, and thence curving southwards, produce a great whirl, as it were, in the Atlantic, in the centre of which there is the still water of the *Sargasso*, or *Grassy Sea*. This area, so called from the vast accumulation of the *Sargassum bacciferum* and other floating sea-weeds, swarms with a Life, vegetable and animal, peculiarly its own, and presents one of the

most remarkable features in the geography of the Atlantic.—Following the southward flow from the Azores, and the south-easterly flow from the south coast of Ireland, against which a minor current (*Rennel's*) from the Bay of Biscay impinges and recoils, there arises a new and increased stream, which holds onwards to the African continent. Of this current, the eastern portion sets in through the Strait of Gibraltar to the Mediterranean, while the western trends southward, and becomes the *North-African and Guinea Current.* This stream, from 150 to 180 miles broad, hugs closely the coast, and for a long part of its course flows in contact with, but counter to, the Equatorial Current, with whose waters it is supposed ultimately to mingle in the South Atlantic.

140. The next and last great current of the Atlantic to which our limits will permit us to advert, is the *Arctic,* or main cold-water stream from the north. Setting strongly down the eastern coast of Greenland, it partly doubles Cape Farewell, where, augmented by the Davis Strait Current, it holds southward to Newfoundland. Arriving at Newfoundland, it sends a branch through the Strait of Belle Isle to the St Lawrence, while the main portion continues its course till it meets the Gulf Stream. Here it divides, one portion flowing southward to the Caribbean Sea, which it enters as an under-current; the other, flowing south-west, forms the United States *Counter-Current.* "The Arctic Current thus replaces the warm water sent through the Gulf Stream, and modifies the climate of Central America and the Gulf of Mexico, which, but for this beautiful and benign system of aqueous circulation, would be one of the hottest and most pestilential in the world."

141. In the more limited and land-locked area of the Indian Ocean, the constant currents are few, and the periodical numerous and important. The *Equatorial* is less defined than in the Atlantic, and consists of a westward tendency of the tropical waters towards the coasts of Africa, where, divided by the large island of Madagascar, one branch sets down with considerable force, and forms the *Mozambique Current;* while another, broader but feebler, trends southward, again to be united with that from the Mozambique Channel. The combined stream, now from 90 to 100 miles broad, with a temperature 7° or 8° above that of the ocean, and with a velocity of 60 or 80 miles a-day, sets in towards the Cape of Good Hope, and constitutes the *Agulhas* or *Cape Current.* Of this current, one main branch, doubling the Cape, flows northward into the Atlantic as far as St Helena; where, meeting the Guinea Current, it is deflected westward,

and merges into the Equatorial of that ocean; whereas another portion, obstructed by the Agulhas bank, is turned back, and, combining with the connecting flow from the Southern Ocean, constitutes the important *Counter-Current* of the Indian Ocean. We say "important" counter-current, for it flows along the direct route to Australia, and with a velocity (after leaving the Agulhas bank) of nearly 50 miles a-day—a motion which, though gradually declining, is still sensibly felt at more than midway between the Cape and Tasmania. North of the equator, the currents and surface-drifts of the Indian Ocean are regulated by the monsoons, and vary, of course, with the seasons; while in the Red Sea, Arabian Sea, Persian Gulf, and Bay of Bengal, they set in and out with the local winds, and often change in a very complicated and capricious manner.

142. The currents of the Pacific are coextensive with its greater area, but are less decided in their courses in consequence of the numerous obstructions presented by its reefs and islands. They are altogether less known than those of the Atlantic and Indian Oceans, and their investigation is greatly complicated by the frequency of counter-currents, surface-drifts, and local gyrations. Being all but excluded from the Arctic Ocean, it is to the great interchange between the cold waters of the Antarctic and the warmer waters of the equator that we must look for the primary impulse of its currents. Beginning with the Antarctic, to which it opens broadly, we have first the *Drift Current* of that ocean setting in towards the north-north-east, then north-east, and lastly towards the east-north-east till it nears the coast of Chili, where it divides—sending one branch south along the coast to form the *Cape Horn Current,* and another northwards to form the *Peruvian Current,* so remarkable for its cold stream along a coast of torrid temperature. This Peruvian, Chili, or "Humboldt's Current" (as it is sometimes called, after its first investigator), has a temperature along more than 400 miles of its course 12° or 14° below that of the surrounding atmosphere, and 8° or 10° below that of the ocean through which it flows. As it holds on to the north it gradually becomes warmer and inclines to the west, till in 20° south latitude it turns fairly to the westward and merges into the great *Equatorial Current* of the Pacific. This vast current, occupying the entire torrid zone, and aided in its westerly flow by the trade-winds and the tidal wave, sweeps boldly across from South America on the one hand to the Indian Archipelago on the other. As it proceeds, it sends off a few minor streams to the north and south, which become *counter-currents,* but the main mass holds onward to the Indian Islands,

where it is broken up into several sections, and becomes further complicated by the *monsoon drifts* of that region. One main portion, however, sets southward with its warm waters along the coasts of Australia, under the name of the *New South Wales Current*, and enters the Antarctic Ocean; while another, still more decided, trends northward of the Philippine Islands, and becomes the well-known *Japan Current.* This last current, like the Gulf Stream of the Atlantic, which it greatly resembles in its course and character, carries the warm waters of the equator to the Northern Pacific; but having but a partial opening into the Arctic Sea by Behring Strait, it sweeps round the Aleutian Isles and shores of Russian America, and returns again, with diminished temperature, to the torrid zone. As it proceeds along the shores of Oregon and California it begins to bifurcate, one branch trending westward into the ocean, and another holding still southward and merging into the waters of the *Mexican Current.* This current, which flows along the coasts of Mexico and Central America, is an alternating rather than a constant one—depending on the monsoons of these coasts, and setting south-eastward during winter and north-eastward during the opposite half of the year. Besides the preceding, other minor currents have been noticed in the Pacific, as the *Carolinian Monsoon Current*—an alternating flow depending on the influence of the Indian and Chinese monsoons; the *Okhotsk Current*—an easterly set of the waters of that sea, arising from the south-east and easterly winds that prevail there during the summer; the *North Equatorial Counter-Current;* and *Mentor's* (after the Prussian surveying vessel of that name) or the *South Equatorial Counter-Current.* These, however, and others of less note, are but partially known; the numerous islands and reefs of the Pacific not only interrupting the regular flow of the major currents, but rendering the minor ones more complicated and less decided in their directions.

143. Such are the principal *constant* currents of the ocean—the *periodical* and *variable* being too multifarious and local for the limits of a general outline. And yet, as regards these latter, it may be observed that some, though variable in volume and velocity, are constant as to direction; and though periodical as to the season of the year, are constant as to the time and extent of their periodicity. The drift-currents of the Indian Ocean which depend on the monsoons (see Winds) are periodical, and yet, one season with another, we may regard them as constant in volume and velocity. The under-currents which set in from the Indian Ocean into the Red Sea and Persian Gulf, and from the Atlantic into the

Mediterranean, are constantly flowing, and yet they will vary in volume and velocity, being greatest from May till October, the season of greatest evaporation in these inland waters. Wherever there are local currents depending on seasonal evaporation, the influx of flooded rivers in spring, or the melting of snow and ice, there will be seasonal variations in the volumes and velocities of these currents, and yet, in a general sense, they may be considered as a part of the constant and permanent machinery of the ocean.

144. In whatever character marine currents may appear, they are all-essential to the equilibrium and uniformity of the ocean. Excessive evaporation in the torrid zone is instantly counterbalanced by an influx from the temperate and frigid. The heated waters of the equator are modified by the colder currents from the poles; while the warmer and lighter waters of the equator flow over to temper the rigours of the polar seas. The salter and denser water of one area subsides and flows off as an under-current to some fresher region; while the fresher and lighter flows in from above to supply the deficiency. The heavier ever descends and the lighter ascends; and thus, vertically as well as horizontally, an incessant circulatory and equalising system is established throughout the expanses of the ocean. The colder ever flowing to the warmer and the warmer to the colder, their influence also extends to that of the lands against which they impinge, and thus additional warmth and moisture are borne to one country and refreshing coolness to another. Climate, and consequently terrestrial life, vegetable and animal, are modified by these currents; and in all likelihood they play equally important parts in the distribution and arrangement of the life of the ocean. Some coursing in shallow streams, and others pressing forward as deep and impetuous rivers, they must exercise considerable influence in transporting and assorting the sediments and debris of the ocean—here laying down long belts of uniform sediment, and there ploughing out deeper troughs and valleys—here arresting the progress of icebergs, that drop their burden of boulders and gravel on one zone, and there fostering the growth of animalcules and zoophytes (foraminifera, corals, &c.), that drop their exuviæ and rear their structures in another zone equally definite and restricted. Besides these great natural functions, they often subserve the purposes of navigation and commerce; and though the steam-ship has rendered the mariner less dependent on winds and tides and currents, he still skilfully seeks to avail himself of the favouring stream of one current and to avoid the opposing influence of another.

145. "The great oceanic currents," says one of the most elo-

quent expounders of our science, "are among the grandest phenomena presented by the wise economy of nature. Their extent, the prodigious length of their course—in some nearly equal to the circumference of the globe—fill us with astonishment, and leave far behind everything of this description to be seen in the water-courses of the continents. Owing to these permanent streams the sea-waters mingle from pole to pole, and move with sleepless flow from the Pacific to the Indian Ocean, and from thence to the Atlantic; and this unending agitation preserves their healthfulness and purity. Like the winds, the currents tend to equalise differences, to soften extremes. The cold waters of the antarctic pole temper the scorching heats of the coast of Peru; the warm waters of the Gulf Stream lessen the severity of the climate of Norway and the British Islands. Their importance is no less in the relations and the commerce of the nations. It is the currents which, together with the winds, trace the great lines of communication upon the highways of the oceans, favouring or obstructing the intercourse of one country with another, bringing near together places apparently the most remote, separating others that seem to touch each other. Their importance in nature and history cannot fail to impress the mind even of the most unobservant."

NOTE, RECAPITULATORY AND EXPLANATORY.

In the preceding chapter, attention has been directed to the waves, tides, currents, and other movements to which the waters of the ocean are generally subjected. Waves are produced by the friction and impact of the winds, and occasionally by earthquake commotions. Wind-waves vary from a mere ripple of the surface to billows 10, 20, 30, and 40 feet in height, according to the power of the wind, the extent of sea, and depth of water; but earthquake-waves have been known to rise to 60 or 80 feet, and, rolling in with wall-like front and greater impetus, are far more powerful and destructive. The latter, however, are rare, and luckily confined to limited areas; while the former may be said to be universal, but varying in magnitude according to the force of the wind, and the extent, depth, and conformation of the sea in which they occur.

Tides are produced by the attraction of the moon and sun acting on the mobile waters of the ocean. In consequence of the earth's rotation there are two tides a-day; and owing to the moon's revolution, and her position as regards the sun, there are two spring-tides and two neap-tides a-month. The moon being the nearer luminary, her attraction or tide-wave compared with that of the sun is as 100 to 38; and from this cause also the difference between spring-tide and neap-tide in any locality is as 7 to 3. Had our planet been covered by a uniform sheet of water, the flow of the great tidal wave would have proceeded with unvarying regularity in time, height, and velocity all round the globe; but owing to the interruption and conformation of the continents, the varying depths of sea, and similar irregularities, it differs in different areas; and yet in each of these areas its rise and fall are as unvarying as the rotation of the earth or the revolution of her satellite.

The currents of the ocean depend chiefly upon the unequal temperatures and densities of its different regions—the colder and warmer, the denser and lighter, the salter and fresher, incessantly tending to interchange and equilibrium. These currents are either constant, periodical, or variable—the constant depending on the primary and established relations of the earth; the periodical on monsoons, tides, and sea and land breezes which occur in certain seas at stated seasons; and the variable on local winds, melting of ice, river floods, and other similar contingencies.

To those who may wish to enter more fully into the consideration of the waves, tides, and currents of the ocean—their directions, volumes, velocities, and causes—we have again to recommend perusal of Captain Maury's 'Physical Geography of the Sea,' the only comprehensive, and at the same time popular, treatise that has appeared on the subject in the English language.

X.

THE WATER—ITS RIVERS AND LAKES.

146. HAVING directed attention to the Water, as manifested in the larger expanses of oceans and seas, we now turn to its minor exhibitions in springs and streams, rivers and river-systems, lakes and lacustrine areas. In the former instance the waters were truly oceanic, and characterised by their *saltness;* in the present instance they are more terrestrial, if we may so speak, and characterised, for the most part, by their *freshness.* They belong, however, to the same great aquatic system. The vapour elaborated from the ocean ascends invisibly and diffuses itself through the atmosphere, where, subjected to colder currents, it is condensed, and becomes visible in clouds, mists, and fogs. Receiving further condensation through greater cold or electrical agency, it returns again to the earth in the form of dew, rain, hail, sleet, and snow. When in the atmosphere, water belongs to the domain of Meteorology; when it returns to the earth, it comes once more within the province of the Hydrographer, who tracks it in spring, stream, and river to the ocean. The circulation of water is incessant: now in the ocean, now in the atmosphere, now in the tissues of plants and animals, now in the crust of the earth, now coursing its surface, and anon in the ocean—again to repeat the same circuit, and this without intermission while the present relations of the universe endure.

147. In general, this circulation is slow and gradual—so slow that the spherule of vapour now rising from the ocean may be years, or even ages, in returning to its native source. Disseminated in the tissues of plants, or locked up in the crystallisation of minerals, its cycle seems interminably arrested; and yet we know that decay and degradation will some day or other bring about its liberation. On certain occasions, however, and in certain localities, its circulation is so rapid that you absolutely perceive the hazy vapour ascending from the sea, rolling landward

in mist and cloud, coming in contact with cold mountain-peaks, condensing into rain, and falling in torrents to augment the runnels and rivulets. From runnel to stream, from stream to river, the

Circulation of Water.

mass swells and hurries downward and onward to the great receptacle whence the light and filmy vapour originally arose, there to renew the same career, and perform analogous functions.

[" Water," says the eloquent author of the 'Physical Geography of the Sea,' "is Nature's carrier. With its current it conveys heat away from the torrid zone, and ice from the frigid; or, bottling the caloric away in the vesicles of its vapour, it first makes it impalpable, and then conveys it by unknown paths to the most distant parts of the earth. The materials of which the coral builds the island, and the sea-conch its shell, are gathered by this restless leveller from mountains, rocks, and valleys in all latitudes. Some it washes down from the Mountains of the Moon, or out of the gold-fields of Australia, or from the mines of Potosi; others from the battle-fields of Europe, or from the marble quarries of ancient Greece and Rome. These materials, thus collected and carried over falls or down rapids, are transported from river to sea, and delivered by the obedient waters to each insect and every plant in the ocean at the right time and temperature, in proper form and in due quantity. Treating the rocks less gently, it grinds them into dust, or pounds them into sand, or rolls and rubs them until they are fashioned into pebbles, rubble, or boulders. The sand and shingle on the sea-shore are monuments of the abrading and triturating power of water. By water the soil has been brought down from the hills, and spread out into the valleys, plains, and fields for man's use. Saving the rocks on which the everlasting hills are established, everything on the surface of our planet seems to have been removed from its original foundation, and lodged in its present place by water. Protean in shape, benignant in office, water, whether fresh or salt, solid, fluid, or gaseous, is marvellous in its power."]

Springs and Streams.

148. The water that falls on the surface of the land is partly and mainly carried off in runnels, partly supplies the wants of plants and animals, and partly sinks into the soil and rocky strata. Percolating the rocks, it collects in chinks, fissures, and other cavities, or, meeting in with some impervious bed, it accumulates in the porous strata above, and there forms extensive sheets of subterranean water. In virtue of the great law of gravity, water is ever tending to lower levels, and thus what gathers in the higher portions of the crust finds its way, in process of time, through rents and crevices, and, springing forth, holds on its course to the valleys below. Where there are no impervious beds in the higher lands to intercept its downward tendency, it often percolates to vast depths, and far below the surface of the adjacent valleys; but sooner or later it is arrested by some obstructing stratum, and there, in obedience to hydrostatic pressure, it bursts forth through the nearest outlet, and rises to the surface with a force proportionate to the height and volume of the accumulated waters. In whatever manner water may accumulate within the crust, or find its way again to the surface, the outlets are known as *springs;* and these springs occur in all countries and at all levels—some issuing with force even from the bed of the ocean. It is usual to speak of them as surface springs and deep springs, as perennial, intermittent, hot, cold, mineral, and the like—characteristics, the consideration of which belongs more, perhaps, to Geology than to Physical Geography.

149. It may be noticed, however, that *surface springs* are those which issue from superficial beds of sand, gravel, and the like, and being immediately dependent for their supplies on the amount of rainfall, are often very feeble or altogether dry in summer, though gushing forth copiously during winter. *Deep-seated springs,* on the other hand, uninfluenced by summer droughts or winter rains, flow steadily at all times—though, generally speaking, the great majority of springs are more or less affected by the seasons. *Perennial springs,* as the name implies, are those that flow year after year without signs of abatement. They are evidently deep-seated, and many that were celebrated by the ancients gush copiously now as they did thousands of years ago. *Intermittent,* on the other hand, are those that well forth at one period, and at another stop suddenly, and seemingly in a capricious manner. They are no doubt connected with subterranean reservoirs, whose waters alternately sink beneath and rise above their outlets;

and this may be occasioned by sudden droughts and rainfalls, by the expansion and escape of steam and gases, by the ebb and flow of tides, and other kindred causes.

150. Surface springs generally vary in temperature with the seasons: deep-seated ones, being beyond these influences, are equable at all times. It was stated in par. 17 that the earth's crust, at the depth of 80 or 90 feet, is unaffected by summer's heat or winter's cold; but that below this depth the temperature went on increasing at the rate of 1° Fahr. for every 60 feet of descent. Springs whose sources are above this invariable stratum will therefore fluctuate in temperature according to the season of the year; those that ascend from beneath it will gradually increase in heat—the deeper being the hotter. Of the latter we have instructive examples in the Artesian wells of France and other countries—those borings emitting water from 60° to 90° and upwards, and this strictly according to depth, and altogether independent of the nature of the strata through which they are carried. *Cold springs* generally flow from chilled mountain sources; *hot springs*, on the other hand, arise either from vast depths, or are situated in the neighbourhood of volcanic action. Thermal and hot springs (hot even beyond the boiling point of water, and accompanied by violent jets of steam) occur abundantly, and on a gigantic scale, in Iceland, the Azores, Central Asia, New Zealand, the Andes, and other volcanic regions; they occur also in Britain, the Pyrenees, Germany, Austria, and other countries far removed from any centre of volcanic activity. Like ordinary springs, hot springs are either perennial or intermittent—perennial, like those of southern France and the Pyrenees, that have flowed without abatement since the time of the Romans; and intermittent, like the Geysers ("roarers") of Iceland and New Zealand.

151. The waters that percolate the earth being of different temperatures, and often containing carbonic acid and other gases, act chemically, less or more, on the rocks through which they pass. In this way they become *mineral springs*—that is, hold in solution various mineral ingredients, which are either deposited along their courses on land, or borne onward to the ocean. Some, for example, are saline, or contain salt; some chalybeate, or contain iron (*chalybs*, iron); some siliceous, or contain flint (*silex*); some calcareous, or contain lime (*calx*); while others give off sulphurous vapours, or are impregnated with the salts of various minerals and metals. Such are the sulphuretted waters of Harrogate, the brine springs of Cheshire, the borax springs of Tuscany, the travertine or lime-depositing waters of the Anio, the siliceous hot springs of Iceland and the Azores, and thousands of others that

occur in almost every country. To the same category also belong escapes of steam, hot mud, and the like, so frequent in volcanic districts; and in the same way may be ranked discharges of gases, naphtha, petroleum, and so forth, which generally come to the surface in connection with water, and are seemingly dependent on its percolating and hydrostatic power. In familiar language the water of mineral springs is spoken of as *hard*, in contradistinction to rain and river waters, which are said to be *soft*—soap readily dissolving in and forming a lather with the latter, but curdling on and refusing to mingle with the former. The quality of mineral springs, as remedial agents, is of general importance, and has long been studied; it is also of special value to the geologist and miner as indicating the nature of the rocks through which the waters percolate.

152. Insignificant as springs may individually appear, they perform in the aggregate most important functions in the economy of nature. If the waters, as they fall from the atmosphere, were immediately carried off by surface-runnels, the earth would at one time be flooded, and at another parched by destructive droughts. Sinking, however, into the soil, and diffused through its mass by capillary attraction, percolating the crust, and accumulating in its fissures and porous strata, this water is stored up, as it were, for future use, and given out by springs in moderate and continuous supplies. These springs are the great vivifiers of external nature, supplying one of the main wants of animal life, and clothing even the desert around them with verdure and blossom. They are also the fountainheads of our streams and rivers, whose channels, but for this incessant discharge from the earth, would often be reduced to a mere succession of stagnant pools, instead of flowing, as they now do, with never-failing currents. Ever silently seeking their way down through the rocky strata, these springs dissolve some minute portion, and carry it to the ocean, there to compensate for the abstraction of mineral ingredients by the plants and animals that inhabit its waters. Acting chemically, this internal permeation of water is evidently connected with the formation of mineral crystals and metalliferous veins, and also with that greater metamorphism of rock-masses by which strata of one nature are in process of time converted into strata of another and very different nature.

153. *Streams*, as explained in par. 43, are formed by the union of several springs, and by the union of one stream with another, till, increasing in breadth and volume, they assume the character of rivers. When mainly dependent on springs (though augmented

by rainfalls), they are said to be *permanent;* but when arising solely from rainfalls, melting of snow, and the like, they are *temporary,* and often of short duration. Permanent streams are usually distinguished, according to their dimensions, as *rills, streamlets, brooks, rivulets,* &c. (each country, and even province of a country, having its own expressive term for such distinctions), and their currents form *ravines, glens, gorges, valleys,* and other descriptive excavations. Temporary streams, on the other hand, are little noticed save in regions subjected to periodical rains, their dry courses being known as *nullahs* in India, *wadies* in Arabia, *creeks* in Australia, and so on in other localities. Streams occur in all countries, but fewest and least, of course, in rainless latitudes. Their great headquarters are the slopes of mountain-chains and the outer margins of valleys, and there they impress on the country geographical features and geological relations peculiarly their own. Coursing down the mountain-sides with headlong speed, they form ravines, gorges, and waterfalls—their excavating power depending primarily upon their volume and velocity; and, secondarily, on the nature of the materials to be eroded. The aggregate amount of debris brought down by streams and torrents is enormous; and one has only to cast his eye over some lofty mountain-slope to see how deeply it is scarred and seamed and furrowed by these restless and resistless agencies. In fact, the great diversity of mountain scenery depends on this erosive power of water—all the hills and highlands depending less for their present outlines on the igneous forces by which they were upheaved, than on the meteoric and aqueous agencies to which they have been subsequently subjected.

154. Streams, like springs, subserve important purposes in the economy of nature. They constitute a great network of drainage for the land—carrying off superfluous moisture, and preventing its accumulations in bogs, swamps, and morasses. They are at once the carriers and distributors of water—dispensing in measured supplies the heavy rainfalls, melting snow and ice of the highlands, to the less rainy regions of the plains below. Geologically, they are incessant workers of change—here cutting out ravines, glens, and gorges—there filling up lakes with the eroded material; here wearing deeper channels for the further drainage of swampy lowlands, and there assisting in that universal transport of sediments to the ocean which is destined to become the strata of future lands. Man, too, ever early locates himself on their banks, employing their perennial supplies in the wants of his home, in the irrigation of his fields, or as a cheap and effective agent in the turning of his machinery. No wonder, then, that in

times more primitive and poetic than our own every spring and stream had its presiding deity and spirit to be worshipped—the untutored mind adoring, in secondary causation, that vivifying principle which the more enlightened intellect can trace to a higher and diviner source.

Rivers—their Characteristics.

155. As streams are formed by the union of springs and minor runnels, so rivers are formed by the union of streams. In general they have their origin in some notable spring, lake, morass, or melting glacier, far up among the mountains. This infant current, augmented by the accession of other springs, becomes a main stream; and this stream, by the influx of other *affluent* or *tributary* streams, very soon assumes the dimensions of a RIVER. A river is thus said to have its *head* or *source* in some higher region; to flow along a certain *course;* to wear out for itself a *bed* or *channel,* whose margins form its *banks;* and ultimately to discharge its waters into some lake, sea, or estuary by a *mouth* or *mouths.* In other words, every river has a *rise, flow,* and *fall,* which form the essential features of its existence. Where the ground, in the ultimate part of a river-course, is low and level, the accumulating waters often discharge themselves by several branches, and form a *delta* (par. 88), as in the Nile, Niger, Indus, Ganges, &c.; and such deltas may be either marine, lacustrine, or fluviatile, according as the rivers flow into the sea, a lake, or another larger river. Where the tides and river-currents contend, there frequently accumulates across the entrance a spit of sand or gravel, known as a *bar;* and these bars are serious impediments to the navigation of some of the finest rivers. As all rivers flow from higher to lower levels, the terms *up* and *down* have reference to this natural condition; and as a spectator descends with the current, the *right bank* lies on his right hand, and the *left bank* on his left. When he ascends, however, this order is reversed—the right bank being then on his left hand, and the left bank on his right.

156. The whole extent of country drained by a river and its tributaries is spoken of as the *basin* of that river (basin of the Thames, basin of the Tay, &c.); and this naturally, from the hollow or valley-shaped aspect which such districts usually assume. As streams unite to form rivers, so several river-basins may descend towards the larger depression of some inland sea; and thus geographers speak of the "basin of the Baltic," the

"basin of the Mediterranean," and, carrying the idea still farther, even of the "basin of the Atlantic." As the great oceans form the ultimate receptacles for all the rivers (with one or two exceptions), the river-basins that descend to any ocean constitute what is termed the *river-system* of that ocean; and thus we have the Arctic System, the Atlantic System, the Pacific System, and the System of the Indian Ocean—together with the Aralo-Caspian System, and the minor basins of Utah, the Mexican table-land, and the plateau of Bolivia, whose streams are strictly continental, and confined to these areas. The line or ridge that separates one basin or system from another basin or system is termed the *watershed* of these basins (or *waterscheid*, if we affect a German derivation)—all the springs and streamlets "shedding or parting off," as if from the ridge of a house, to their respective areas. Though hills and mountains generally form the boundaries between river-basins, it does not follow that watersheds should always consist of elevated ground—a few feet of fall being sufficient to determine the current in either direction. The low ridge that thus separates the streams of different basins is spoken of as a *portage* (Fr.), from the fact that goods and boats are frequently carried across from one stream to another; and thus, it may be, completing the passage by water from one side of a continent to another.

157. Such are the usual *terms* employed by geographers in treating of rivers; the *characteristics* of the rivers themselves—that is, their rise, course, length, volume, depth, velocity, capability of navigation, and the like—require more detailed consideration. As to their *rise*, it has been already stated that it generally takes place in some upland spring, lake, or morass, and not unfrequently in the melting terminus of some descending glacier. Many of these springs, especially those issuing from chasms and caverns in limestone districts, are often of considerable magnitude, being, in fact, full-flowing streams when they make their appearance at the surface. Mountain lakes, being the recipients of springs and other runnels, become in like manner copious sources—the streams that flow from them being already rivers in miniature. The same may be said of morasses and high swampy tracts, which, being saturated with springs and rainfall, discharge at once regular and continuous streams. Where a mountain lake receives a number of small feeders, it is justly regarded as the "source" of the river to which it gives rise; but where one of the feeders assumes decided importance, that feeder is looked upon as the infant river, and must be traced to a higher and farther fountainhead among the mountains. Glaciers and melt-

ing snows are also occasional sources, and, where merely accessories, become important regulators of supply in the regions where they occur—their waters flowing freest when the summer's heat has most diminished the lowland streams.

158. Whatever their origin—and it must be confessed that the exact sources of many of our larger rivers are unexplored and undetermined—their *courses* are primarily directed by the general slopes of the continents. In the Old World, the great slopes being north and south, the principal rivers flow in these directions, just as in the New World their courses are easterly and westerly, in obedience to the relief of that continent. But while this is true, and necessarily so, as regards the main slopes, it should be borne in mind that there are many causes tending to modify the courses and directions of rivers. Among these, for example, may be noted the strike of the secondary hills and spurs, which are usually at right angles to the main chains; the occurrence of lines of fracture in the crust; the passage from one formation to another whose strata lie in a different direction; and the alternation of softer and harder beds—the current readily excavating its channel in the line of the former, but obstructed and turned aside in another direction by the latter. All these, and many other circumstances, concur to give streams and rivers very irregular courses, winding and bending, turning and returning, but still guided in the main by the primary slope of the region.

159. As to the *length* of their courses, that will depend primarily upon the extent of the region through which they flow—the larger area giving scope to the longest river; and, secondarily, upon the bendings and windings to which they may be subjected. The direct distance between the source and outlet of a river may not exceed two hundred miles, and yet its absolute course, through all its doublings and windings—its *development*, as it is termed—may amount to a thousand. This absolute length gives no true idea, however, of the importance of a river, either in nature or to navigation—its value mainly depending on the permanence of its volume, its depth, and velocity. The *lengths of rivers*, so often tabulated in geographical works, are, for the most part, little better than guess-work, and, even were they more accurate as to figures, they are still of little use—the real natural and economical value of a river resulting, as we have already said, from the permanence of its volume, the slowness of its current, its depth, nature of channel, accessible entrance, and influx and efflux of the tides.

160. The *volume*, size, or magnitude of a river—that is, the quantity of water which its channel contains—depends on many collateral circumstances, but chiefly on the extent of country

drained by its affluents. There may occasionally be some peculiarity of basin as regards rainfall, melting of snow, and the like; but, generally speaking, the greater the area over which the tributaries ramify, the greater the quantity of water brought to the main trunk or channel. In temperate latitudes this volume is somewhat lessened in summer and increased in winter; but on the whole the supply is pretty equable and permanent. Sudden excesses, arising from heavy rainfalls, rapid melting of snow in spring, and the like, are merely temporary, producing what are termed *floods*, *freshets*, and *debacles*. In tropical countries, on the other hand, where the rains fall and the snows melt only at stated seasons, these floods assume the character of regular and *periodical inundations*. And where the rain falls in the low countries at one period, and the far-off mountain-snows melt at another, there may be two such inundations occurring with wonderful regularity both in time and amount of overflow. Again, where the sources of a river lie near the equator and its outlet in the temperate zone (as in the case of the Nile), a considerable time must elapse between the equatorial rainfall and the deltic inundation; and the length of this lapse will depend partly on the windings of the river, and partly on the slope and freedom of the channel. In the preceding instances, whether subjected to irregular floods or periodical inundations, the river itself is always more or less *permanent*; but in some regions, as Australia and South Africa, many of their so-called rivers are merely *temporary*, being roaring impetuous torrents during the rains, and a succession of stagnant pools and dry shingly reaches during the season of drought.

161. The *velocity* of a river depends mainly on the slope or declivity down which it flows, partly on the nature of its channel, according as this may be straight or winding, deep and narrow, or wide and obstructed by rocks and shoals, and partly also on the amount or volume of its current. As all rivers descend from higher to lower regions, and many of them from very elevated sources, they may be said to have an upper, middle, and lower course—the *upper* being characterised by rapidity of stream through gorge and glen and waterfall; the *middle* by less velocity through rapids and cataracts; and the *lower* by a quiet steady flow through level and alluvial plains. Other things being equal, the deeper the river, the more rapid the current—the greatest velocity being in the centre of the stream, and a little below the surface, where there is least retardation from friction on the sides and bottom of the channel. "The speed, however," it has been well remarked, "does not depend entirely either upon slope or depth,

but also upon the height of the source of the river, and the pressure of the body of water in the upper part of its course ; consequently, under the same circumstances, large rivers run faster than small, but in each individual stream the velocity is perpetually varying with the form of the banks, the winding of the course, and the changes in the width of the channel."

162. The velocity of rivers is an all-important consideration in their geographical, geological, and commercial relations. The more rapid their currents, the less the irrigating effect, and the greater the geological effect on the countries through which they flow; and in proportion as their velocity increases, so their fitness for the purposes of navigation is diminished. Formerly a descent of more than 1 foot in 200 was considered unnavigable; and though the power of steam has enabled man to contend with higher velocities, it is still the velocity of current more than the depth of water that renders a river unavailable as a means of internal communication. Geologically, the cutting as well as transporting power of rivers is greatly aided by the rapidity of their currents; hence the effect of mountain torrents compared with the quiet, sluggish flow of the lowland river. It has been calculated, for example, that a velocity of 3 inches per second will tear up fine clay, that 6 inches will lift fine sand, 8 inches sand as coarse as linseed, and 12 inches fine gravel; while it requires a velocity of 24 inches per second to roll along rounded pebbles an inch in diameter, and 36 inches per second to sweep angular stones of the size of a hen's egg. During periodical rains and land-floods the currents of rivers often greatly exceed this velocity; hence the tearing up of old deposits of gravel, the sweeping away of bridges, and the transport of blocks many tons in weight—an operation greatly facilitated by the circumstance that stones of ordinary specific gravity (from 2.5 to 2.8) lose more than a third of their weight when immersed in water.

163. The *depth* of rivers is as various as the circumstances under which they occur, though, generally speaking, the greater the volume of water, the deeper the channel of excavation. In their upper and middle courses, the stream, being for the most part through steep rocky excavations, is of no great depth ; but in the lower and slower portion the waters accumulate and deepen as they proceed. The *outlet*, or *embouchure* (Fr.), as it is frequently termed, depends altogether upon the conformation of the country. Some rivers discharge themselves at once and by a single mouth into the ocean; others into an estuary, and are consequently affected for a certain length by the flux and reflux of the tides; while others, again, creep sluggishly along, branching and bifur-

cating through their swampy deltas, till they find their way into the sea by several main mouths. Seeing that the conditions of rivers are so exceedingly varied, their *facilities for navigation* will depend in each case on the nature of the outlet as accessible from sea and free from bars and banks, on depth and volume of water, and on the velocity of the current. Length of course and volume of current may be obstructed by rocks and shoals; depth and volume may be rendered unavailable by shallow bars and shifting sandbanks.

River-Systems, Oceanic and Continental.

164. It will be seen from what has been stated respecting the characteristics of rivers, that each has its own individuality, and that this individuality depends in the main on the geographical position, extent, and superficial configuration of its basin. To give an account of these basins would be to describe in detail the rivers that traverse the surface of the globe—a subject which extends beyond our limits, and belongs more especially to hydrography and general geography. All that our outline will permit is the arrangement of the basins into SYSTEMS, and a notice of some of the more remarkable rivers that belong to each system. As all the affluent streams of a river belong to one basin, so all the river-basins that descend to the same ocean-basin—whether directly, as the Niger to the Atlantic, or intermediately through some inland sea, as the Nile to the Atlantic through the Mediterranean—belong to the same river-system. In this way we have four great *oceanic river-systems*—the Arctic, Atlantic, Pacific, and Indian; and one or two minor *continental* ones, as the Aralo-Caspian, the Utah, the Mexican, and the Bolivian. To the main characteristics of these respective systems, and the leading rivers that compose them, the attention of the student is now directed.

165. The *Arctic System*, as the name implies, embraces those rivers which, obeying the northern slope of the Old and New World continents, discharge themselves into the basin of the Arctic Sea. Lying for the most part within the limit of constantly-frozen ground (See Atlas, Plate XII.), and flowing through notably level plains, there is a degree of sameness in the conditions of these waters which renders the Arctic more homogeneous in its character than any other river-system. For convenience, however, it may be divided into three sections—Asiatic, European, and American—according as the rivers belong to these respective areas.

166. The Asiatic section comprehends the great Siberian rivers —the Kolyma, Indigirka, Lena, Olenek, Yenesei, and Obi, which, rising in the Altai, Yablonoi, and Stanovoi mountains, receive numerous tributaries in the upper and middle stages of their course, wind slowly through the plains, and ultimately discharge themselves by wide estuarial mouths into the Arctic Sea. The largest of these are the Lena, Yenesei, and Obi, which, had they discharged themselves into temperate or tropical seas, would have taken rank with the noblest rivers on the globe. As it is, they are little known, and of little geographical importance: and here the student has an instructive example of how much relative position has to do with the physical and vital features either of land or of water. The Lena, which rises in the mountains north of Lake Baikal, has a development or winding course of 2400 miles, receives several important tributaries (Vitim, Olekma, and Aldan), and is computed to drain an area of 594,000 square miles. It is a deep sluggish stream in the lower part of its course, and finds its way into the sea between high banks of frozen mud and sand, in which are imbedded the remains of mammoth, rhinoceros, and other huge mammals, which in former ages (upper tertiary), and under different geographical conditions, inhabited the plains of northern Asia. The Yenesei is still larger, having a development of 2800 miles, and a basin of not less than 784,000 square miles. It receives several large affluents—the Great and Little Kem, the Angara from Lake Baikal, and the Upper and Lower Tongouska, most of which, in their upper and middle stages, are impetuous torrents, interrupted by rapids and cataracts. The Obi, or Irtish-Obi, as it may be termed from the equal importance of its two main branches, is the most notable of these rivers, having a development by either branch of 2400 miles, and a conjoint basin embracing nearly one-third of the entire area of Siberia. It rises in the Lake of Toleskoi (Lake of Gold) in Great Tartary, and after leaving the mountain region its current is said to be scarcely perceptible—having a fall of only 400 feet or thereby in a distance of 1200 miles! As already mentioned, the main affluent of the Obi is the Irtish, and the Irtish receives in turn the streams of the Tobol and Ishim. One leading characteristic of all the Siberian rivers is, that though rapid and sufficiently diversified in the upper stages of their courses, they become sluggish and monotonous on entering the low boggy plains. Frozen, like the ocean into which they enter, for many months of the year, they are unfit for navigation; while, on the melting of the snows in their upper and more southerly sources, the swollen floods, finding an insufficient outlet by the level, ice-locked, and

more northerly mouths, overspread the country in lakes and morasses, which render its surface still more dreary and inhospitable.

167. The European section of the Arctic river-system embraces the Petchora, which falls directly into the ocean, and the Mezen, Dwina, and Onega, which enter it indirectly through the White Sea. With the exception of the Dwina, on which Archangel is situated, and which drains an area of 106,000 square miles, none of these rivers are of much importance, being usually ice-locked from September to June, and otherwise flowing through a flat and uninviting region. This flatness, however, permits of an extended canal-system; and it is thus that the White Sea and Baltic are connected, through these northern rivers and the Volga, with the Black Sea and Caspian, just as they will shortly be by the more rapid and effective system of railway.

168. The American section comprises those streams and rivers which, obeying the northern slope of that continent, find their way through a labyrinth of lakes and swamps, and ultimately fall into the Arctic Sea. The more noticeable of these are the Great Fish, the Coppermine, the Mackenzie, and the Colville. Comparatively little is known of the sources and ramifications of these rivers, of which the Mackenzie is the largest and most important. This great river, which drains an area of 441,000 square miles, is formed by the union of several streams that rise in the eastern slopes of the Rocky Mountains. The most important of these are the Athabasca and Peace rivers, which, after passing through Lake Athabasca, unite to form the Slave River; and this, after entering the Slave Lake, reissues as the Mackenzie. Like the rivers of Siberia, those of Arctic North America flow through low, frozen, and inhospitable swamps, and enter the sea by wide mouths; but, unlike those of Siberia, they are connected with a labyrinth of lakes, a feature peculiarly characteristic of the northern section of the American continent.

169. The *Atlantic System*, as the name implies, embraces all those rivers that find their way directly or intermediately into the great basin of the Atlantic from the slopes of the adjacent continents. It necessarily arranges itself into four sections—the European, African, North American, and South American, according as the rivers descend from either of these continents In the European section we have certain rivers that flow into the Atlantic directly, and others that enter it indirectly through the Baltic and Mediterranean. The chief of those flowing into it directly are the Elbe, Weser, and Rhine from the western slopes of the Germanic plain; the Seine, Loire, and Garonne from

France; and the Duero, Tagus, Guadiana, and Guadalquivir from the Spanish peninsula. The Rhine—the "beautiful Rhine" of the Germans—springs from Alpine glaciers at an elevation of 7650 feet, descends rapidly to Lake Constance (1250 feet), thence through the Falls of Laufen to Basel (800 feet), and thence, with a navigable course, to the North Sea, which it enters by the largest of European deltas. The Rhine has thus a well-marked upper and lower course, a development of 600 miles, and a drainage of 65,000 square miles; the Loire an absolute course of 520 miles, and a drainage of 33,000 square miles; while the Tagus, the third in importance, has a length of 400 miles, and a drainage of 21,000 square miles. The principal streams that discharge themselves through the intermediate basin of the Baltic are the Neva, Niemen, Vistula, and Oder—all more or less obeying a north-westerly slope, and, like their recipient, ice-locked for a considerable portion of the year. Of these the Vistula (whose windings are said to be nearly equal to nine-tenths of its direct course from source to mouth) has the greatest development and drainage—its length being 520 miles, and its basin 56,000 square miles.

170. The waters that fall from the European side into the basin of the Mediterranean are—the Ebro and Rhone into the main sea; the Po into the Gulf of Venice; and the Danube, Dnieper, Dniester, and Don into the Euxine Sea. The Rhone rises among the Alps at an elevation of 5500 feet, and, having an actual course of only 500 miles, is necessarily one of the most rapid rivers in Europe. It has a drainage of 23,000 square miles, discharges itself by two main mouths, and, when in high flood, projects its current with such force that its fresh waters can be skimmed from the surface several miles out at sea. The waters that enter the Black Sea branch of the Mediterranean basin obey the great southern and south-eastern slope of the European continent. Of these the Don, Dnieper, and Dniester have comparatively gentle currents, and all in their lower courses flow through flat, swampy plains, which, during a large portion of the year, are little better than quagmires and morasses. The Danube, the most important of the suite, rises in the Black Forest at an elevation of 2850 feet, has a winding course of 1496 miles, and an area of 234,080 square miles. Originating in the union of several mountain-streams, it is first known as the Donau or Danube in the Duchy of Baden, from which it runs through an Alpine country to Ulm, and thence to Passau it traverses the plain of Bavaria. From Passau to Vienna it runs through a second hilly region, and the remainder of its course is generally through a flat country, except on approaching the rocky defile of the "Iron Gate," till its embouchure by three

main mouths into the Euxine Sea. The Danube, with its navigable tributaries—the Theiss, Drave, and Save—form important channels of internal communication for eastern Europe—an importance that has been greatly enhanced by the adoption of steamers fitted to the peculiarities of their currents.

171. Such are the principal rivers of Europe that fall directly or indirectly into the basin of the Atlantic. Lying in the temperate zone, and having their sources at no great distance from the ocean, their volumes are wonderfully regular and persistent, being merely liable to occasional floodings from excess of rainfall, or from sudden meltings of the snow in early spring. The extent and configuration of the continent prevent the formation of large and long rivers; but as the rapids and waterfalls are confined to their upper stages, the lower portions of their courses are in most instances easy of access and more or less navigable. Whether viewed as channels of drainage and irrigation, or as means of internal communication, these rivers constitute an essential feature in the physical geography of Europe. Flowing from the central region in every direction, they equalise the water-supply more than in any other continent, confer greater beauty and amenity on its surface, and afford at once a perennial supply and an available mode of intercommunication to its busy populations.

172. The African section of the Atlantic system embraces all those rivers which flow from the western and northern slopes of that continent—the former discharging themselves directly into the ocean, the latter indirectly through the basin of the Mediterranean. Of those entering directly into the Atlantic, the Senegal, Gambia, Niger, Congo, Coanza, and Orange are the more important, though still but very partially known in their middle and upper courses. The Senegal and Gambia, which rise in the Kong Mountains, and have courses from 600 to 850 miles in length, form the conjoint basins of Senegambia, and are navigable to some extent. The Niger, the noblest of these western rivers, is supposed to have its sources in the northern slopes of the Kong Mountains, and, after a circuitous course of more than 1500 miles, during which it receives the Chadda and other large tributaries, enters by several navigable mouths the Gulf of Guinea. The Niger (Joliba or Quorra) drains an immense but unknown extent of tropical Africa; has a navigable middle course of many hundred miles, varying from one to six miles in width, and running at the rate of five and eight miles an hour; and possesses a low, pestilential delta of 32,000 square miles, alternately choked with the rankest jungle-growth and overspread by inundation, which attains its

height about the middle of August. The Congo and Coanza are so far navigable, but are unknown in the interior, though supposed to be connected with that maze of rivers now known to occupy the central table-land. The Orange or Gariep is unnavigable, being alternately a large impetuous torrent during the rains, and a shallow shingly stream during the season of drought.

[The preceding, indeed, is less or more the character of all the South African streams—"dry rivers," as they are sometimes not inappropriately called, during seasons of drought, and foaming torrents immediately after rainfall. The following passage from Andersen's 'Lake Ngami' very graphically delineates the nature of this occurrence:—

"About two years from the period of which I am now writing, I happened to be on a visit to Barmen, on which occasion I witnessed one of those extraordinary phenomena only to be seen to perfection in tropical climes. One afternoon heavy and threatening clouds suddenly gathered in the eastern horizon: the thunder rolled ominously in the distance, and the sky was rent by vivid lightnings. Knowing from long experience its imports, we instantly set about placing everything under shelter that could be injured by the wet. This was hardly accomplished when large heavy drops of rain began to descend, and in a few seconds the sluice-gates of heaven appeared to have opened. The storm did not last above half an hour; but this short time was sufficient to convert the whole country into one sheet of water. The noise, moreover, caused by the river and a number of minor mountain-streams as they rolled down their dark muddy torrents in waves rising often as high as ten feet, was perfectly deafening. Gigantic trees recently uprooted, and others in a state of decay, were carried away with irresistible fury, and tossed about on the foaming billows like so many straws. Every vestige of many gardens was swept away; and some of the native huts, which had been imprudently erected too close to the river, shared a similar fate. Indeed, it must have been a miniature deluge."]

173. The most important, and indeed the only African river that discharges itself into the Mediterranean, is the Nile—the most classical, and in many respects the most remarkable, river in the world. Flowing from the equatorial lake, Victoria N'yanza (3740 feet above the sea-level), as the Bahr-el-Abiad, or White Nile, it receives, after a considerable course, the Bahr-el-Azrek, or Blue Nile, from the Galla country, and after a further tract is augmented by the Atbara from Abyssinia—the conjoint stream flowing downward through Dongola, Nubia, and Egypt (a distance of 1200 miles), without receiving any additional accession of waters. The total length from Lake N'yanza is about 2300 miles, and its supposed drainage-basin not less than 600,000 square miles. Nothing is yet known with certainty of the feeders of N'yanza and other supposed adjacent lakes, which in all likelihood derive their head-waters from the snowy ranges of equatorial Africa; but the upper course of the river is described by Captain Speke as flowing through a beautiful and fertile country: its middle course through Nubia is marked by a succession of low rapids or "cataracts," nine or ten in number; and, its lower course having a fall of only two

inches a-mile, the current flows gently through the plains of Egypt, till its final discharge into the Mediterranean by the two main mouths which form its delta. This delta commences 90 miles from the sea, and has a coast-line of 187 miles between its main mouths, the Rosetta and Damietta. In the plain of Egypt, which is from 2 to 18 miles in width, the current of the Nile, when not in flood, is about 2½ miles an hour, but in its delta branches the flow is almost imperceptible. The most remarkable feature in the Nile is the regularity of its annual inundation, which arises, in all likelihood, from rainfalls dependent on the south-east trade-winds of the Indian Ocean, and on the melting of snows among the equatorial ranges near its sources. In its upper branches the river begins to rise in April, but at Cairo the flood is not perceptible till towards the summer solstice. It then continues to rise for nearly a hundred days, and remains at its greatest height till the middle of October, when it begins to subside, and reaches its lowest point in April and May. So far as we have evidence, this inundation has remained unchanged for the last 4000 years. Its height in Upper Egypt is from 30 to 35 feet, at Cairo from 20 to 24, and in the northern part of the delta, where it spreads out over a wider area, it seldom exceeds 4 or 5 feet. The fine black slime or mud deposited by this inundation has been the unfailing source of wealth and fertility to Egypt, and from its accumulation, in like manner, has arisen the formation and increase of the delta.

[Speaking of the source of the Nile, Captain Speke in his 'Journal' affirms that "the most remote waters, *or top head of the Nile*, is the southern end of the Lake N'yanza, situated close on the third degree of south latitude, which gives to the Nile the surprising length, in direct measurement, rolling over thirty-four degrees of latitude, of above 2300 miles, or more than one-eleventh of the circumference of the globe. Now, from this southern point, round by the west, to where the *great* Nile stream issues, there is only one feeder of any importance; for the travelled Arabs one and all aver, that from the west of the snow-clad Kilimandjaro to the first degree of south latitude there are salt lakes and salt plains, and the country is hilly, not unlike Unyamuézi; but they said there were no great rivers, and the country was so scantily watered, having only occasional runnels and rivulets, that they always had to make long marches in order to find water when they went on their trading journeys; and further, those Arabs who crossed the strait when they reached Usoga, as mentioned before, crossed no river either. There remains to be disposed of the 'salt lake,' which I believe is not a salt, but a fresh-water lake; and my reasons are, as before stated, that the natives call all lakes salt, if they find salt beds or salt islands in such places. Dr Krapf, when he obtained a sight of the Kenia mountain, heard from the natives there that there was a salt lake to its northward; and he also heard that a river ran from Kenia towards the Nile. If his information was true on this latter point, then, without doubt, there must exist some connection between his river and the salt lake I have heard of, and this in all probability would also establish a connection between my salt lake and his salt lake, which he heard was called

Baringo. In no view that can be taken of it, however, does this unsettled matter touch the established fact that the head of the Nile is in 3° south latitude, where, in the year 1858, I discovered the head of the Victoria N'yanza to be." Again, referring to the river as it issues from the lake by the "Ripon Falls," he says—"Though beautiful, the scene was not exactly what I expected; for the broad surface of the lake was shut out from view by a spur of hill; and the falls, about 12 feet deep and 400 to 500 feet broad, were broken by rocks. Still it was a sight that attracted one to it for hours,—the roar of the waters, the thousands of passenger-fish, leaping at the falls with all their might; the Wasoga and Waganda fishermen coming out in boats, and taking post on all the rocks with rod and hook; hippopotami and crocodiles lying sleepily on the water; the ferry at work above the falls, and cattle driven down to drink at the margin of the lake, made in all, with the pretty nature of the country—small hills, grassy-topped, with trees in the folds, and gardens on the lower slopes—as interesting a picture as one could wish to see." And as the young river held on its downward course, the country and scenery were most beautiful. "It was the very perfection of the kind aimed at in a highly-kept park; with a magnificent stream from 600 to 700 yards wide, dotted with islets and rocks, the former occupied with fishermen's huts, the latter by sterns and crocodiles basking in the sun,—flowing between fine high grassy banks, with rich trees and plantations in the background, where herds of the nsunnu and hartebeest could be seen grazing; while the hippopotami were snorting in the water, and florikan and guinea-fowl rising at our feet."]

174. The rivers of South America constitute by far the most unique and gigantic section of the Atlantic system. Indeed, all the rivers of that continent obey its great eastern slope towards the Atlantic—the streams that flow down the abrupt and rainless counterslope towards the Pacific being mere runnels fed by the melting snows of the Andes. In this case we have at once area for development, supply from heavy rainfalls engendered by the moisture-laden winds of the Atlantic, as well as from melting snows and perennial springs, and breadth of volume arising from the flatness of the surface over which these rivers flow. Beginning at the south, the rivers of Patagonia are of little importance, being described as "of small magnitude, with few or no affluents, and making straight across the dry shingly terraces of that sterile region." North of this the great river-system commences, embracing the basins of the Plata, the San Francisco, the Paranahyba, the Tocantins, the Amazon, Orinocco, and Magdalena.

175. The Rio de la Plata, whose drainage is estimated at 886,000 square miles, receives its affluents from very distant and different regions—the Salado, Vermejo, and Pilcomayo from the deserts and salinas of the Lower Andes—the Paraguay and Parana, two noble rivers, from the wooded slopes and verdant plains of the central regions—and the Uruguay from the low sierras and valleys of southern Brazil. Some of these affluents, like the Paraguay and Parana, are navigable for hundreds of miles inland, and, on the whole, have deep and accessible channels, but are subject to

periodical and destructive inundations. Their united waters meet in the estuary of the Plata—a fresh-water sea, 180 miles long, and 120 broad at its entrance; but shallow and loaded with mud, whose discoloration is perceptible far out the Atlantic. The San Francisco, having a length of 1400 miles, and an estimated drainage of 187,000 square miles; the Paranahyba, having a drainage of 115,000 square miles; and the Tocantins, or Para, of 284,000 square miles,—are strictly Brazilian rivers, rising among, and flowing between, the sierras of that country. Little is known of their sources, but they descend with considerable currents till they enter the lowlands that fringe the Atlantic, from which they are navigable for long distances inland.

176. The Amazon, by far the largest river in the world—having a length of 3500 miles from its remotest feeder (the Apurimac) in the Andes to its union with the ocean, and an estimated drainage of 1,512,000 square miles—is that which gives life and character to the lowlands of tropical America. Entering the ocean by an estuary 200 miles long and 130 broad, its freshening influence is felt several hundred miles out at sea; while, on the other hand, the tidal rise is perceptible at the distance of 576 miles from the embouchure. The main stream, though much impeded by mud-banks and islands, is navigable for 2000 miles inland, and will, one day or other, become the highway of commerce and civilisation to the fertile and exuberant region through which it flows. Its principal affluents on the right are the Xingu, Tapajos, Madeira, Purus, and Ucayali, which flow from the sierras of Brazil and the central region; and on the left the Rio Negro, the Japura, and Putumayo, which descend from the mountains of Parimé and the northern Andes. Many of these tributaries are largely navigable, and, though treated as mere feeders of the Amazon, would be esteemed important rivers in the geography of other countries. The head-waters of the Amazon drain the entire circle of the middle Andes, almost connecting its stream by a low portage with the Paraguay on the south, and actually uniting it by the Casiquiare with the channel of the Orinocco on the north. Like other tropical rivers, the Amazon is subject to periodical inundation—its waters beginning to rise in December, being at their greatest height in March, and lowest in July and August. When in flood, its waters overspread an immense extent of country, which thus becomes alternately a fresh-water sea, and *selvas* teeming with the rankest tropical vegetation.

177. The Orinocco—the last of South American rivers to which our space will permit us to advert—has a basin of nearly 300,000 square miles, and a navigable course at all seasons of more than

1000 miles. Rising in the mountains of Parimé, it takes a circuitous course northwards and then eastwards, receiving on the one hand several important tributaries from the Andes, and on the other a number of smaller streams from the ranges of the Parimé. Increased by these affluents—the Guaviare, Meta, and Atures on the left, and the Paraqua and Caroni on the right—it ultimately finds its way by a perfect labyrinth of mouths into the basin of the Atlantic, whose tides flow upwards into its main channel for more than 250 miles. Its annual floods take place with great regularity—commencing about the end of March, and decreasing by the end of August. During high flood, thousands of square miles of the low flat basin are inundated to a depth of 30 feet—these flats, alternately flooded and covered with long rank grass, constituting the celebrated *llanos* of the Orinocco.

178. The river-systems of North America are governed by the disposition of the Rocky Mountains much in the same way as those of South America are governed by the Andes. The counter-slope of the Rocky Mountains, being less abrupt than that of the Andes, gives development to two or three streams of some importance on the Pacific side, but in the main the great river-basins are directed towards the Atlantic. The central plain that stretches from the Gulf of Mexico to the Arctic Sea being divided by a low watershed of 1300 or 1500 feet, a few rivers, as the Mackenzie and Coppermine, trend northward to the Arctic basin, but all the larger and more important lie south of this watershed, and belong to the Atlantic system. Of these the Rio del Norte and the Mississippi fall into the Gulf of Mexico; the St Lawrence directly into the Atlantic; and the Saskatchewan and Churchill into Hudson Bay. The Rio del Norte, which rises among the sierras of New Mexico, has its upper course through a desert region, in which it receives few affluents; but as it descends into the lower grounds it gains considerable accessions, and becomes a natural boundary between the United States and New Mexico. Its drainage area is estimated at 180,000 square miles.

179. The Mississippi ("father of waters") is by far the largest of North American rivers. Rising in the small lake of Itasca, on the verge of the middle table-land, at an elevation of 1500 or 1600 feet, it runs southward through the great central plain, receiving numerous accessions from either side, and, after a winding course of 3160 miles, falls through a swampy delta into the Gulf of Mexico. Its main tributaries on the right or Rocky Mountain side, in which they take their rise, are the Missouri—a river even longer, larger, and having more affluents, than the Mississippi itself—the Arkansas, having also many affluents, and the Red

River; while on the left its chief tributary is the Ohio, with its numerous feeders from the western slopes of the Alleghanies. Between the Rocky Mountains on the west, and the Appalachians on the east, lies, therefore, the great conjoint basin of the Missouri, Mississippi, and Ohio, having an area of more than a million square miles; containing every description of soil and scenery—prairie, barren, and woodland; watered by innumerable streams and several navigable rivers; and possessing every variety of climate, from the coldly-temperate highlands of Nebraska to the sub-tropical warmth of the Gulf of Mexico. The Mississippi, we have said, has a winding course of 3160 miles, but if the Missouri be taken as the main stream, its length is 4260 miles; while that of the Arkansas is 2000, and the Ohio more than 1000 miles. The breadth of the Missouri and Mississippi at their confluence is about half a mile, and the main stream downwards is very little more. Though gentle, the current is by no means sluggish; and thus, during floods, from the melting of the snow in the higher latitudes, the rivers sweep downwards immense quantities of mud, driftwood, and other debris. The Missouri is said to be navigable "from the Great Falls in the Rocky Mountains to the sea, a distance of 4000 miles; the Mississippi, from those of St Anthony, 2240; while the Ohio, being connected by a system of canals with Lake Erie, and thence to Lake Ontario, carries out a water-communication between the Gulfs of Mexico and St Lawrence." The delta of the Mississippi, which projects itself forward into the Gulf of Mexico, is a low and unhealthy region, nearly 14,000 square miles in area, and full of lagoons, creeks, and pestilential marshes.

180. The St Lawrence, which forms the great water highway to Canada, takes it rise, under the name of the St Louis, far west in the central lake-region of North America. After uniting the Lakes Superior, Huron, Erie, and Ontario, it issues from the last by the name of the Iroquois, and, alternately contracting and expanding into lake-like reaches, it is known as the St Lawrence at Montreal, from whence it flows to Quebec, and thence by its long estuary into the Atlantic. Its drainage basin is estimated at 297,000 square miles, of which 94,000 or more is covered by fresh-water lakes. Its estuary is 350 miles long, and 80 broad as its mouth, but, from its northward trend, is frozen and ice-locked during the winter. The Saskatchewan and Churchill take their rise, in like manner, among the labyrinth of lakes that characterises the extreme northern plain of America, and, after flowing from lake to lake with irregular and tortuous courses, find their way to the North Atlantic through Hudson Bay. The basin

of the Saskatchewan is estimated at 300,000 square miles, and that of the Churchill at 73,000, but a large portion of both is occupied by lakes and frozen morasses.

181. Encompassed as the *Pacific* is by the continent of America on the one hand, and by that of Asia on the other, its *river-system* is altogether peculiar, and disproportionate to the encircling areas. On the American side, from Tierra del Fuego to the Gulf of California, there is not a single stream of importance: and from that point northward to Behring Strait the only rivers of note are the Colorado, rising among the sierras of New Mexico, draining, with its tributaries, an arid and rocky area of 170,000 square miles, and falling into the Gulf of California; the Columbia, with its main tributary the Lewis, descending with impetuous current over waterfalls and cataracts from the Rocky Mountains, traversing the Oregon territory, and draining an area computed at 194,000 square miles; and the Frazer, an equally rapid stream, rising among the ranges of the Rocky Mountains, and watering the wild but picturesque country of British Columbia. Abutting as the Andes and mountains of Mexico do upon the very shores of the Pacific, there is no space for the development of rivers; and it is only where the Rocky Mountains bend inland, and are flanked by minor hill-ranges, that the Colorado, Columbia, and Frazer make their appearance.

182. On the Asiatic side of the Pacific the case is altogether different, the mountains from which the rivers descend being not only far inland, and thus affording ample area for development, but being, moreover, the recipients of abundant rain and snow fall. We have thus, descending the eastern slopes of Asia, the Amoor in Chinese Tartary, the Hoang-Ho, Yang-tse-Kiang, and Tche-Kiang in China, and the Menam and Mekong in Cochin-China—all first-class rivers—besides a vast number of affluents and minor streams that add to the fertility and importance of that region. The Amoor (Tunguse, "Great Water" of the Manchoos, Sagalhien, or "Black Water") rises high in the Daurian Mountains, receives several large tributaries in its descent, and, after a course of 2400 miles, enters as a navigable river into the land-locked Gulf of Tartary, which opens on the one hand into the Sea of Okhotsk, and on the other into the Sea of Japan. It drains a computed area of 583,000 square miles; and, from its navigable capabilities, safety of entrance, and relative position to Japan and Russian Siberia, is likely to become of considerable commercial importance. The great rivers of China—the Hoang-Ho and Yang-tse-Kiang—take their rise among the Kihan-shan and Kuen-lun Mountains, that buttress the plateau of Tartary, and

after making their descent between the minor ranges of the Yun-ling and Pe-ling, wind with slow and steady flow through the plain of China into the Yellow Sea. The course of the Hoang-Ho, or Yellow River (so called from the colour of its waters), is estimated at 2300 linear, and its basin at 537,000 square miles; while the course of the Yang-tse-Kiang is 2900 linear, and its drainage area not less than 548,000 square miles. Though their main mouths are wide apart, yet they may be said to fall into the same delta—their broad navigable streams being united throughout their lower courses by innumerable canals and natural channels. Indeed the whole country, from the southernmost branch of the Yang-tse, north to the Pei-ho, or White River, which enters the Pe-che-le Gulf, is one alluvial flat, intersected by channels, canals, and embankments, and liable to be flooded and broken in upon by shiftings of the river-courses, and other similar changes. The burden of sediment which these rivers carry down to the shallow basin of the Yellow Sea is immense; and though frequently shifting their channels, and encumbered by sandbanks, they are navigable by vessels of considerable burden for 600 or 800 miles, and by smaller craft to perhaps double that extent. The Mekong is a large but little-known river, rising in the mountains of Eastern Assam, flowing with a long course between the mountain-ranges of Cochin-China, draining, along with the Menam, an estimated area of 216,000 square miles, and falling into the Gulf of Siam or Cambodia by a many-mouthed delta.

183. *The river-system of the Indian Ocean* has three separate and independent sections—the Asiatic, the Australasian, and the African, according as the rivers flow from either of these regions. The Asiatic embraces the Martaban and Irawady in Burmah; the Brahmapootra, Ganges, and Indus in India; and the Tigris and Euphrates in Persia and Asia Minor. The Martaban, Irawady, and other rivers of Further India, occupying the narrow valleys which lie between the parallel hill-ranges of that region, flow southward in long and comparatively straight courses. Very little is known of their sources or affluents; but the Irawady, which enters the Gulf of Martaban by a many-branching delta, is navigable for 400 or 500 miles, and though encumbered in its lower course by mud-banks and islands, is a channel of vast importance to the Burmese empire. During the season of inundation it spreads to a breadth of 3 or 4 miles, runs at the rate of 4 or 5 miles an hour, and is heavily laden with sedimentary debris. There is, indeed, a great similarity among all the rivers of the Indo-Chinese peninsula, whether flowing like the Menam and

Mekong into the Pacific, or like the Martaban and Irawady into the Indian Ocean: they have long straight courses, flow with considerable current through a country rich in tropical vegetation, and enter the sea by several mouths through low and gradually-increasing deltas.

184. The Ganges, which rises at an elevation of 13,000 or 14,000 feet among the glaciers of the Himalaya, descends rapidly to the plain of India, and there flowing with gentle current it receives numerous affluents from the southern slopes of its parent mountains on the one hand, and from the northern slopes of the Vindhya high grounds on the other, till it ultimately falls through a many-branching delta into the Bay of Bengal. The Brahmapootra ("offspring of Brahma") is formed by the union of two main streams, the Dzangho-chur, which has its origin in the northern slopes of the Himalayas, and flows eastward till its union with the Brahmapootra proper, which, descending from the distant recesses of the Tibetan mountains, runs southward towards Assam. After their junction the united waters, under the name of the Brahmapootra, cut transversely the eastern Himalayas, and then, flowing south and westward with a volume considerably exceeding that of the Ganges, enter the delta of that river about 40 miles above the sea, but still maintain the individuality of their own channel. The conjoint area drained by these rivers and their affluents (several of which are larger than the Rhine) is estimated at 432,000 square miles, and their respective lengths at 1680 miles. Like other tropical rivers, the Ganges and Brahmapootra are subject to annual inundations—the floods commencing in April, attaining their maximum about the middle of August, and continuing till October. They begin first to swell from the melting of the snows among the mountains, but before this influence has reached the low grounds these are widely under water from the periodical rainfalls. The quantity of water arising from these two causes and brought down by the Ganges and Brahmapootra is enormous, overspreading the plains for hundreds of square miles, and freshening more or less the whole upper area of the Bay of Bengal. The amount of sediment brought down by these rivers when in flood is also immense; and the whole delta, 200 miles in length and 180 broad at its base, with all its channels, creeks, lagoons, and mud-islands (Sunderbunds), is clearly the offspring of this debris. Though liable to sudden shiftings during inundations, several of the branches of the Gangetic delta are navigable at all seasons for vessels of large draught; while the main stream can be ascended by smaller craft to the foot of the Himalayas. Though possessing a large

volume, the Brahmapootra, from the rapidity of its current and the obstacles in its channel, is of less importance as a means of internal communication.

185. The Indus, the third great river of India, takes its rise in the highlands of Thibet, and after a precipitous course through the western Himalayas, descends into the plains, where it is augmented by the streams of the well-known Punjab, or Five Rivers. These affluents, like the main stream, are the offspring of the Himalayas, and drain a large expanse of upland as well as fertile lowland. After their union near the southern extremity of the Suleiman hills, the Indus receives no more tributaries of any note, but flows with gentle current through a somewhat arid country for nearly 300 miles, and then forks into a delta 80 miles long by more than 100 broad at its base, discharging itself by many mouths, only three or four of which are navigable. The annual floods commence with the melting of the Himalayan snows in April, attain their greatest height in July, and terminate in September. The winding course of the river is nearly 2000 miles, and its estimated drainage 312,000 square miles; but owing to the shallow and shifting nature of its mouths it is navigable only by vessels of comparatively small burden. Lying open to the great tidal wave of the Indian Ocean, it has, like the Ganges, a rapid and dangerous *bore*, which ascends the main channels to a distance of 60 or 70 miles.

186. The only rivers of importance that enter the Indian Ocean from western Asia are the Euphrates and Tigris—celebrated in ancient history, and still flowing through a fine but neglected country. Their conjoint drainage-basin is roughly estimated at 200,000 square miles, and both have well-marked upper, middle, and lower courses. The Euphrates and its affluents rise in the table-land of Armenia, and after a long and tortuous course the main river descends in rapids through the Taurus chain into the plain of Mesopotamia. The Tigris and its tributaries rise in a similar manner to the east, in the highlands of Kurdistan, pierces also in its middle course the Taurus chain, and thence descends by a slow and winding channel through the Mesopotamian plain. Both rivers flow parallel for a long distance through this beautiful lowland, and ultimately join at Korna, a distance of 150 miles from the head of the Persian Gulf, which receives their united waters. The development of the Euphrates, the greater river, is estimated at 1600 or 1800 miles, fully one-third of which flows through a plain naturally one of the most fertile and exuberant. "The banks of the Tigris and Euphrates, once the seat of an extensive population, and of art, civilisation, and industry (Babylon, Nineveh,

&c.), are now, however, nearly deserted, covered with brushwood and grass, dependent on the rivers alone for that luxuriant vegetation which, under an admirable system of irrigation, formerly covered them." The floods of the rivers are said to be very regular in their rise and fall—beginning in March, and attaining their greatest height in June.

187. Australia, owing to its geological conformation, is singularly destitute of rivers—those descending the eastern counterslope of its hills into the Pacific being mere streams, while those flowing from their western slopes seem to lose themselves in the great central and yet unexplored plain. The Murray, with its tributaries the Darling, Lachlan, and Murrumbidjee, are the only known rivers of note, and these, though roaring torrents during the rains, are often reduced to a mere chain of ponds and creeks in the dry season. Of the African rivers that enter the Indian Ocean, geography knows too little as yet to offer anything like reliable description. So far as known, the Zambesi, now under exploration by Dr Livingstone, is the largest and most important, apparently draining an immense extent of inland country, which spreads out in plain-like expanses, reticulated by lakes and streams that flow during the periodical rains, but are desiccated and partially obliterated during the season of drought. On the whole, recent investigation seems to point to the interior of Central Africa as a plateau-shaped plain, deriving its main water-supply from rains, which form, for the most part, only temporary streams and lakes —the surplus being carried off by evaporation rather than by a regular system of stream and river drainage.

188. Such is a brief outline of the chief river-systems of the world—the Arctic, Atlantic, Pacific, and Indian. Though the basins of which they are composed have their own individual characteristics, there is still a great similarity, and necessarily so, among the various members of a system. Thus the rivers of the Arctic system run more or less meridionally, flow from *warmer to colder* latitudes, and all their embouchures are for a large portion of the year ice-locked and impervious to navigation. By the melting of the snows in their upper courses they are flooded before the thaw has reached their lower waters, and thus the plains through which they pass are largely occupied by lakes and morasses. The rivers that descend the southern slopes of Asia, Europe, and North America, flow also in meridional courses, but pass, on the contrary, from *colder to warmer* latitudes, and consequently their embouchures are open at all seasons. Those of them that belong to the Atlantic system derive their floods chiefly from the melting of

the snows along their upper courses; while the inundations of those belonging to the Indian system depend partly on the melting of the snows and partly on the periodical rainfalls in their lower courses. With the exception of the Rio del Norte and the Mississippi on the one hand, and the rivers that enter the Mediterranean on the other, all the basins of the Atlantic system, whether from the American, European, or African continents, run in latitudinal courses; and thus, from their sources to their embouchures, each passes along the same climatological zone. These and other great conditions must at once present themselves to the mind of the inquiring student, and produce the conviction that the idea of *river-systems* has something more to recommend it than the mere convenience of artificial arrangement.

189. Besides the oceanic systems there are what have been termed *Continental Systems*—a few inland basins cut off from all connection with the ocean, and having the equilibrium of their waters maintained by evaporation and absorption. The chief of these, as already mentioned, are the Aralo-Caspian basin in Asia; the Utah and Mexican in North America; the basin of the Andes plateau in South America; and in all likelihood, when better known, some similar depressions in Australia and Central Africa. On referring to the map it will be seen that a number of the streams of Central Asia—the Asiatic plateaux—run inland to lakes or lose themselves in the sand and shingle of the desert. This is the "Basin of Continental Streams" in Asia, and includes the Lob, Balkash, Helmund, and other lake-hollows, with their tributary streams; the Aral, with its main feeders the Syr and Amoo; and the Caspian, with its rivers the Oural and Volga. Of these the most important is the Volga, which rises on the Valdai slopes at an elevation of 550 feet, and, after a long and winding course of 2400 miles, during which it receives many important tributaries (the Kama, Viatka, &c.), falls by two main mouths into the Caspian Sea, which is 82 feet below the level of the Euxine. The Volga is the largest river in Europe, has a fall of only 633 feet during a course of 2400 miles, drains an estimated area of 397,640 square miles, and constitutes the great internal water-way of Russia. The seas and lakes of this basin, as indeed of all other continental basins, having no escape for their waters save by evaporation, must necessarily be more or less salt; and hence the saline peculiarities of the Caspian, Aral, Balkash, Dead Sea, Lake of Utah, and others occurring in these so-called "basins of continental streams." Basins of this kind necessarily occur in rainless flats and plateaux; for were the amount of rainfall exceeding the

evaporation, the sheets of water would accumulate till they overflowed their margins, and found an outlet, like other lakes, towards the nearest oceanic area.

ABSTRACT OF RIVER-SYSTEMS.

ARCTIC.

	Drainage Basin.	*Length.*	*Development.*
	Sq. m.	Geog. m.	Geog. m.
Obi,	924,800	1276	2320
Yenesei,	784,530	1228	2800
Lena,	594,400	1280	2400
Kolyma,	107,200	440	800
Indigirka,	86,400	500	910
Olenek,	76,800	600	1000
Anadir,	63,400	...	...
Dwina,	106,400	380	864
Petchora,	48,800	360	600
Mesen,	30,580	...	...
Saskatchewan,	360,000	924	1664
Mackenzie,	441,600	964	1154
Churchill,	73,600	668	850
Albany,	52,800	380	560

ATLANTIC.

Neva,	67,200	315	440
Rhine,	65,280	360	800
Vistula,	56,640	280	520
Elbe,	41,860	344	684
Oder,	39,000	280	480
Loire,	34,000	320	520
Duna,	33,440	280	560
Niemen,	32,180	240	400
Duero,	29,250	260	440
Garonne,	24,450	200	320
Seine,	22,620	220	340
Tagus,	21,960	360	480
Guadiana,	19,360	240	420
Guadalquivir,	15,000	180	260
Weser,	13,100	200	280
Minho,	11,840	108	192
Nile,	520,200	1320	2300
Rhone,	29,950	232	352
Po,	28,160	248	560
Ebro,	25,100	268	420
Danube,	234,080	880	1496
Dnieper,	169,680	548	1080
Don,	168,420	408	960
Dniester,	23,050	360	440

	Drainage Basin. Sq. m.	*Length.* Geog. m.	*Development.* Geog. m.
Great Lakes and St Lawrence, .	297,600	860	1800
Connecticut, ...	8000	231	270
Delaware, ...	8700	180	265
Orinocco, ...	252,000	370	1350
Essequibo, ...	61,650	350	420
Amazon, ...	1,512,000	1548	3080
Tocantins, ...	284,480	990	1120
Paranahyba, ...	115,200	560	744
S. Francisco, ...	187,200	870	1400
La Plata, ...	886,400	1028	1920
Mississippi-Missouri, . . .	982,400	1412	3560
Rio del Norte, ...	180,000	1220	1840
Magdalena, ...	72,000	560	830
PACIFIC.			
Amoor, ...	582,880	1200	2380
Yang-tse-Kiang, ...	547,800	1550	2880
Hoang-Ho, ...	537,400	1150	2280
Tche-Kiang, ...	99,200	480	960
Columbia, ...	194,400	576	1360
Colorado, ...	169,000	512	800
INDIAN OCEAN.			
Ganges and Brahmapootra, .	432,480	821	1680
Indus, ...	312,000	900	1900
Menam, ...	216,000	600	1490
Euphrates, ...	195,680	600	1500
Godavery, ...	92,800	540	750
Kistua, ...	81,000	440	690
Irawady, ...	331,000	1100	2200
CONTINENTAL SYSTEMS.			
Volga, ...	397,400	900	2400
Oural, ...	53,200	550	...
Kour, ...	64,600	300	640
Sir, ...	237,000	600	1200
Amoo, ...	193,000	800	1400
Lob Lake, ...	177,000	620	1000

Lakes and Lacustrine Areas.

190. *Lake* is the general term for any considerable body of standing water surrounded by land, and not directly connected with the sea or any of its branches. Lakes are thus strictly terrestrial expanses, and belong to the land as much as the streams and rivers that channel its surface. Wherever there is a depression of that surface beneath the surrounding country or the bed of the nearest river, there water will accumulate (unless carried off by evaporation) till it rises above the lowest part of the enclosing

margin and flows off by some river-channel. In this way we may have sheets of all sizes, from the merest pools to lakes occupying many thousands of square miles. Lakes generally consist of *fresh water;* but some, like the Caspian and Aral, having no river of discharge, are *salt,* while others, having only partial outlets, are *brackish.* They occur in all regions, but most abundantly on mountain table-lands and plateaux, and on the lower reaches of great plains. Wherever there is a want of declivity, or any obstruction to the natural flow of the surface-waters, there lakes will accumulate, and this in proportion to the extent of country, the magnitude of the obstruction, and the amount of rain and snow-fall. In consequence of less evaporation, they occur also more abundantly in low than in high latitudes; and hence their frequency and magnitude in the northern regions of America, Europe, and Asia, as compared with other areas.

191. It is usual to arrange lakes into *four* kinds:—1. Those that have neither outlet nor inlet—subterranean springs and rain supplying the water, and evaporation carrying off the excess. These are generally of small dimensions—lowland pools, mountain tarns, and not unfrequently the craters of extinct volcanoes. 2. Those which have an outlet, but receive no running water, being fed by springs rising from their bottoms and rocky margins. Lakes of this class are also small, and for the most part situated in upland districts. 3. Those which, like the Caspian and Aral, receive streams of running water, but have no visible outlet—the balance of level being maintained by evaporation. Such lakes are more or less impregnated with saline matter; and this saltness must be still on the increase. 4. Those that both receive and discharge streams of running water, and which form alike the most numerous and most extensive in both hemispheres.

192. To whatever class they belong, lakes form essential elements of diversity in the landscape, and perform important functions in the economy of nature. Exposing considerable surfaces to evaporation, they serve to temper the aridity of their respective districts, at the same time that they act as so many reservoirs, in which the superabundant supplies of winter are stored up for the increased requirements of summer. In many instances they act as checks to the too rapid discharge of rivers—retaining for perennial supply what would otherwise be run off in a few days, and restraining, moreover, the destructive flood which is brought to rest in their placid areas. Occurring so frequently in the course of rivers, they act as settling pools for the debris and sediment of their waters—the streams they discharge being pure and pellucid, whilst those they receive may be turbid and laden with impuri-

ties. In this way they get gradually silted up, and form rich alluvial tracts, the while that their outlet-currents are deepening their channels and forming the means of a more efficient drainage. In this way lakes become important agents in the surface-modification of the land; and one has only to cast his eye over the fertile dales and vales of long-established regions to perceive how much of these areas was at one time a mere succession of lakes and morasses. Biologically, too, these fresh-water sheets become the habitats of a peculiar flora and fauna—thus extending the range of Life, and affording conditions of existence that no other habitat could supply.

193. In Europe there are two main lake regions—a highland and a lowland; the former embracing the picturesque lakes of Britain, Switzerland, and Italy; the latter the numerous sheets that stud the Baltic provinces of Russia, Prussia, and Sweden. The highland lakes generally occupy the deep narrow troughs of mountain-glens, and from their situation and adjuncts are celebrated for their scenery; the lowland, on the other hand, spread over areas little depressed beneath the surrounding country, and are for the most part tame and unattractive. The waters of Highland or Alpine lakes are usually retained by rocky barriers, through which the outflowing stream is gradually deepening its channel, and thus their dimensions become less and less as the drainage outlet becomes deeper. On the contrary, the drainage of lowland sheets is often slow and sluggish; hence a large portion of their areas is little else than morass, which the accumulation of aquatic vegetation and sedimentary matter is year after year converting into alluvial land.

194. With two or three exceptions (Platten See, Nieusidler See, &c.), the European lakes, strictly so called, consist of fresh water; they have all, or nearly all, streams of ingress and egress; vary in size from a few hundred square yards to several thousand square miles; rise slightly with the rains of winter and fall with the droughts of summer. The more notable of those in the northern lowland region are Lakes Ladoga 6330 square miles, Onega 3280, Saima 2000, Peipus 1250, and Enara 1200 square miles, in Russia; and Lakes Wener 2130, Wetter 840, and Maelar 760 square miles, in Sweden—the latter being only three or four feet above the level of the Baltic. The larger Alpine lakes are on the Swiss side; Geneva or Leman, 240 square miles, at an elevation of 1230 feet; Constance, or the Boden See, 228 square miles, at an altitude of 1250 feet; Neufchatel, 114 square miles, and 1440 feet high; Lucerne, 98 square miles, and 1430 feet high; and Zurich, 74 square miles, at an elevation of 1330 feet: while

on the Italian side there are Garda 182, Maggiore 150, and Como 66 square miles, at elevations respectively of 320, 680, and 685 feet. In the British Isles, Loughs Neagh, Corrib, Erne, and Loch Lomond, respectively 150, 63, 56, and 45 square miles in area, and 48, 31, 130, and 22 feet in elevation, are the largest, though others of smaller dimensions are better known for their picturesque scenery and associations.

195. In Asia, the lakes occupy three main and distinctive regions—the mountains and plateaux of the central highlands, the alluvial lowlands of China and Siberia, and the depressed areas of the Aralo-Caspian and Dead Sea. Unlike those of Europe, many of the Asiatic lakes are salt or brackish, and this peculiarity belongs more especially to those having no river of outlet. Respecting these salt or brackish sheets, accounts differ considerably as to the amount of saline matter held in solution in their waters—a difference that may arise either from taking the specimens at different places, at different seasons, or from errors in analyses. Whatever the source of error, there can be no doubt that where new saline supplies are continually carried in by rivers and springs, and none carried off by running water, the percentage must be gradually on the increase. Of the *saline* lakes the more important and better known are the Caspian (slightly fresher than the ocean), 82 feet beneath the level of the Black Sea, having an area of 130,000 square miles and an extreme depth of 960 feet; the Aral, 36 feet above sea-level, and having an area of 26,000 square miles; Balkash or Tengiz, having an area of 7000 square miles; Urumiah (25 per cent of salts), 1800; Van, 1600; Zurrah, 1600; Tongri-nor, 1800; Koko-nor, 1500; Lob, 1300; and the Dead Sea, 360 square miles, with a depression of not less than 1312 feet beneath the level of the Mediterranean, and containing from 25 to 26 per cent of saline ingredients. Of the *fresh-water* sheets the largest is Baikal (the "Holy Sea" of the Russians) in Siberian Tartary, with an area of 14,800 square miles, and at an altitude of 1535 feet; and Tong-Ting, Poo-Yang, and Tai-Hou in China, having respectively areas of 2000, 800, and 700 square miles, and all valuable aids to the internal communication, commerce, and agriculture of that peculiar country. Besides these may also be noted Zai-zan in Mongolia, 1000 square miles; Booka-nor in Tibet, 1000; Erivan in Armenia, 500; and Tiberias in Syria, 76 square miles, at a depression of 328 feet beneath the Mediterranean.

196. In Africa there are several lakes less or more known to geographers; but while the internal configuration of that continent remains undetermined, it is impossible to arrange them into

anything like systems or areas. Between the Atlas range and the Sahara, and fed by streams from the former, there exists a series of minor lakes, of which the largest (Loudeah, &c.) lies in Tunis; in the hilly region of Nigritia the existence of sheets of considerable magnitude (Tchad, Dibbie, Fittie, &c.) has been so far determined; in the equatorial region, Victoria N'yanza, Baringo, and other reservoirs of the Nile; and in the southern table-land, several shallow and apparently fluctuating sheets (Ngami, Nyanja, Taganyika, &c.) have been partially explored. Among the longer known lakes may be mentioned Dembea or Tzana in Abyssinia, at an elevation of 6270 feet, and embracing an area of 1400 square miles; the deltic areas of Menzaleh and Mareotis in Egypt; and the salt-water lake of Assal in Abyssinia, extending to 30 square miles, and lying in a depression 570 feet beneath the level of the Red Sea. With regard to Australia, we know that certain areas covered with water during the rains are but marshes or mud-pools during the season of drought, and that, along many portions of the sandy coasts, there exist saline and brackish lagoons; but we are yet too slenderly acquainted with the interior to speak with certainty as to the existence of *lakes*, in the true sense of the term, either fresh-water or saline.

197. In South America there are comparatively few lakes, and these, for reference sake, may be arranged into three distinctive regions—namely, the mountain-glens and depressions of the higher Andes; the low plains that border the eastern flanks of the Andes; and the still lower river-plains that trend toward the Atlantic. Of the Andian lakes the most remarkable is Titicaca, situated at an elevation of 12,847 feet, embracing an area of 3800 square miles, and stamping peculiar features on the scenery, life, and civilisation of the surrounding district. It is fed by several streams from the Andes, but discharges itself by a single outlet, the Desaguadero, which after a short course disappears, partly by evaporation and partly by absorption into the sandy and arid soil through which it flows. Of the lakes that skirt the Andes on the east, many of them are of temporary nature, being extensive sheets during the rains, but mere marshes and salt pools (*salinas*) during the period of drought. In the lower plains of the Plata, Amazon, and Orinocco there exist many creeks, lagoons, and stagnant areas that appear in the dry season as lakes, and during the rains as one vast area of inundation.

198. In North America the lakes may be said to affect only two main districts—a highland and a lowland; the former the troughs and depressions of the Rocky Mountains from Panama on the south to Columbia on the north, and the latter the north-

ern section of the great central plain from the southern boundaries of Canada to the Arctic Ocean. In the former area the more important sheets are Nicaragua, 3500 square miles, at an elevation of 128 feet, Maragua, 450 square miles, and Yojoa, 150 square miles, in Central America; Chapala in Mexico, 1000 square miles; and in the United States, Utah, 150 square miles, and the Great Salt Lake, 1800 square miles, at an elevation of 4200 feet. Of the lowland section the more important and extensive are the great "fresh-water seas" that form the lacustrine chain of the St Lawrence. These are Superior, with an area of 32,000 square miles, an altitude of 628 feet, and a depth of 900 feet; Michigan, 24,000 square miles, altitude 574 feet, and depth 1000 feet; Huron, 20,000 square miles, altitude 574, and depth 1000 feet; Erie, 9600 square miles, altitude 565, and depth 84; and Ontario, 6300 square miles, altitude 232, and depth 500 feet. Besides these, there is the immense lacustrine net-work of the extreme north, forming with that of Canada a lake-region unsurpassed by any other on the globe. Of the larger of these boreal, shallow, marshy, and long-frozen lakes we may enumerate Great Bear, 19,000 square miles; Great Slave, 12,000; Winnipeg, 9000; Winnipegoos, 3000; Athabasca, 3000; Deer, 2400; Manitoba, 21,000; Wollaston, 1900; and Lake of the Woods, 1200 square miles.

NOTE, RECAPITULATORY AND EXPLANATORY.

In the preceding chapter attention has been directed to what may be termed the *terrestrial* waters of the Globe—that is, to the springs, streams, rivers, and lakes that occur on the land in contradistinction to the great united mass which constitutes the Ocean. Though separable in this way, it is still the same vast volume of waters we have to deal with, its appearance on the land being only local and temporary. The vapour exhaled from the ocean is conveyed to the land, where, condensed into rains and snows, it falls and forms springs and streams, and these by their union give birth to rivers and lakes. But the stream and river are ever hurrying to the ocean again—again to be evaporated as *fresh water*, again to fall as rain and snow, and again to course the dry land, and to carry with them a portion of those ingredients which, accumulating within certain limits, constitute the peculiar *saltness* of the ocean. The rain and snow that percolate the rocky crust reappear at the surface as *springs*, which, according to their situation, may be superficial or deep-seated; according to their supply, temporary, intermittent, or perennial; according to their temperature, cold or thermal; and according to the rocky material through which they pass, either pure or mineral —that is, impregnated less or more with saline, calcareous, siliceous, chalybeate, and other mineral and metallic substances. By their union, springs and surface rivulets form *streams*, and these streams occurring most abundantly in hilly regions unite, one with another, as they descend to the plains, and there ultimately form *rivers*, whose continually augmented volumes constitute one of the most important features in the hydrography of the globe.

The highest or farthest-off spring to which we can trace a river constitutes its *source* or *rise;* and from this source, through all its windings till it finally falls into the sea by one or by many mouths, lies its *course*. It is usual to divide river-courses into upper, middle, and lower stages—the upper being characterised by ravines and waterfalls, the middle by rapids and cataracts, and the lower by a broad gentle current which often finds its way into the ocean by several branches through a low-lying and marshy delta. The track worn or hollowed out by running water constitutes its *channel*, and the land that forms the margins of this channel is known as its *banks*—that on the right hand as we descend the current being termed the right bank, the left hand the left. The streams that enter any river or main current from either side form its affluents or tributaries, and the entire expanse of country drained by a river and its tributaries is said to be the *basin* of that river. An ideal line, connecting the ultimate sources of all the tributaries of a river, forms the *watershed* of its basin; and generally speaking, the ridge from which the streams of a country flow in opposite directions is the watershed of that region. As all the streams of a river-basin fall to the lower level of that basin, so several river-basins may descend to the still broader basin of some sea or ocean, and all such basins discharging themselves into the same sea constitute a *river-system.*

The river-systems are necessarily coincident with the great oceans into which they flow; and thus we have the Arctic, the Atlantic, Pacific, and Indian systems, together with a few inland systems whose streams flow towards certain depressed areas altogether cut off from connection with the ocean. These are, the Aralo-Caspian basin, the Utah, the Mexican, the Bolivian, &c., whose waters flow inwards to certain lakes, and are thence carried off by evaporation. Where the slopes of a country are pretty uniform, the surface waters are at once carried off by streams and rivers; but where any unusual depression occurs, there they accumulate and form *lakes* and *morasses*. Most of these lakes both receive and discharge running water; but some of a small size, being fed by springs and reduced by evaporation, neither receive nor discharge running water; while others again receive streams and rivers, but have no outlet—their surplus waters being carried off by evaporation. The former set of lakes are always fresh; the latter, like the Caspian, Aral, and Dead Sea, always less or more brackish and saline.

The student who desires more minute details on this portion of his subject will find ample data as to lengths and developments of rivers in the 'Royal Physical Atlas' of A. K. Johnston; as to towns and populations which their waters have attracted to their banks, in the 'Manual of Modern Geography' of Mr Mackay; as to physical features and functions in 'Rain and Rivers' of Col. Greenwood; as to hydrographical characteristics in general, in 'Der Wasser,' a German publication of great merit; and much information of an instructive kind may be gleaned from books of travel devoted to the exploration of such rivers as the Amazon, the Niger, Nile, Indus, Ganges, and Yang-tse-Kiang. Indeed, considering the attractions which all river-banks present to mankind, savage or civilised, there are few things so interesting in geographical descriptions as the ascents of rivers; and these the student should lose no chance of carefully perusing.

XI.

THE ATMOSPHERE—CLIMATOLOGY.

Nature and Constitution of the Atmosphere.

199. HAVING, in the preceding chapters, directed attention to the leading features of the Land and Water—the mountains, table-lands, and plains of the one, and the seas, lakes, and rivers of the other—we now proceed to consider the main relations of the Atmosphere or aërial envelope (Gr. *atmos*, vapour, and *sphaira*, a sphere) by which the whole is surrounded. What is the nature and composition of this envelope, what its capacity for heat and moisture, what are the motions to which, as an elastic fluid, it is subjected, and generally, what are its conditions as the great medium of climate (heat, cold, winds, rains, &c.) on which the Life of the globe is so intimately dependent? This varied subject of climatology belongs more especially to the science of Meteorology; but as an integral portion of the globe, and bearing on everything—organic and inorganic—that presents itself at the surface, the atmosphere and its principal phenomena become important themes to the student of Physical Geography.

200. As already stated in paragraph 19, the atmosphere surrounding the globe, and partaking in all its motions of revolution and rotation, is an aëriform fluid consisting of nitrogen and oxygen gases—79 parts of the former to 21 of the latter by volume, together with a small and variable percentage (.05 to .10) of carbonic acid gas and other impurities. These gases are merely in a state of admixture or diffusion, as is also the invisible vapour which less or more is ever present in the atmosphere. This special composition is alike indispensable to vegetable and animal life. Both animals and plants breathe, if we may so speak, the air; but while carbonic acid is exhaled by the former, it is absorbed and assimilated by the latter, which in turn exhale oxygen for the requirements of the animal kingdom. By this means the

balance of composition is harmoniously maintained, any local variations being too unimportant to affect the general result. Being an elastic or compressible medium, the air nearest the sea-level, pressed upon by all the superincumbent mass, is denser than that at considerable elevations; and by calculating the rate at which this rarity takes place, it is estimated that, at the height of 45 or 50 miles, the atmosphere becomes so rare or attenuated as to be inappreciable. What the *absolute* height or extension may be is still an undetermined problem—90 miles, 212 miles, and even greater altitudes being given, according to the principles on which the calculations are founded.

201. The mean pressure of the atmosphere taken at the sea-level is usually reckoned at 14¾ lb. avoirdupois (14.7304 lb.) upon the square inch—a pressure which, being equal on all sides, is insensible to living structures, the only inconvenience being experienced at great altitudes (5 or 6 miles), where the air becomes too rare and light to maintain respiration, or to retain sufficient heat for the functions of vitality. This aërial pressure is balanced by a column of mercury 30 inches in height; hence the construction of the *barometer*, and hence also the term *barometric pressure* as applied to the oscillations of the atmosphere, which sometimes rise above and at other times fall below this normal standard. The pressure or weight diminishing as we ascend, the barometric column will fall in proportion, and this fall (correction being made for varying effects of temperature) becomes a convenient measure of altitude. Thus, at the sea-level, near the foot of Chimborazo, Humboldt found that the barometer stood exactly at 30 inches, while at the elevation of 19,332 feet, to which he ascended, it fell to 14⅔ inches. Again, under the normal pressure of the atmosphere, water at the level of the sea boils at the temperature of 212° Fahr.; but as the pressure becomes less, ebullition takes place sooner, and thus, as we ascend, the boiling point diminishes, and may in like manner be taken as a measure of altitude. Of course, water at 212° and water at 190° (the boiling point at 13,000 feet in the Andes) will produce very different effects, absolute temperature and not mere ebullition or bubbling-up under diminished pressure being the test of its heat.

202. The atmosphere being the medium through which the sun's heat is conveyed to and from the earth, the lower and denser strata absorb the greatest amount and are necessarily the warmer; hence, as a general rule, temperature decreases with the height to which we ascend from the surface, but not uniformly, as has been established by the recent balloon ascents of Mr Glaisher. As air is expanded by heat and contracted by cold, the warmer

and lighter volumes will ascend, and the colder and denser rush in from all sides to supply the vacancy. In this way currents or *winds* are originated in the atmosphere, and on these currents depend in a great measure the essentials of climatic diversity. As a property of the gaseous or aëriform nature of the atmosphere, the vapour or minute watery vesicles, generated from the earth's waters by the heat of the sun, ascend and are diffused through its mass in an invisible state. This humidity of the atmosphere also decreases with the height, and this in so rapid a ratio that at the altitude of 5 or 6 miles it is all but inappreciable. These vapours, invisible at first, become visible on being condensed by colder currents; hence arise fogs, mists, rains, snows, and other kindred phenomena. The effective portion of the atmosphere, so far as its heat and moisture are concerned, lies, therefore, within a few thousand feet of the earth's surface, all above the limit of 5 or 6 miles being inoperative or nearly so in the production and regulation of climate. As the atmosphere is the medium through which the sun's heat is conveyed to and disseminated over the earth, so also it is the medium of his light-giving rays. Heat and light are alike indispensable to plants and animals, and, from the peculiar constitution of the atmosphere, as regards its varying density, moisture, &c., both are reflected and diffused so as to become most available to vegetable and animal life.

[With regard to the *functions of the atmosphere*, the following beautiful passages from the pen of our early friend and fellow-worker—the late Dr George Buist—will be appreciated by the student whose mind is duly alive to the chain of harmonies that links together the remotest members of our cosmical system:—"We have already said that the atmosphere forms a spherical shell, surrounding the earth to a thickness which is unknown to us, by reason of its growing tenuity, as it is released from the pressure of its own superincumbent mass. Its upper surface cannot be nearer to us than fifty, and can scarcely be more remote than five hundred miles. It surrounds us on all sides, yet we see it not; it presses on us with a load of fifteen pounds on every square inch of surface of our bodies, or from seventy to one hundred tons on us in all, yet we do not so much as feel its weight. Softer than the finest down, more impalpable than the finest gossamer, it leaves the cobweb undisturbed, and scarcely stirs the lightest flower that feeds on the dew it supplies: yet it bears the fleets of nations on wings around the world, and crushes the most refractory substances by its weight. When in motion, its force is sufficient to level with the earth the most stately forests and stable buildings, to raise the waters of the ocean into ridges like mountains, and dash the strongest ships to pieces like toys. It warms and cools by turns the earth and the living creatures that inhabit it. It draws up vapours from the sea and land, retains them dissolved in itself or suspended in cisterns of clouds, and throws them down again, as rain or dew, when they are required. It bends the rays of the sun from their path to give us the aurora of the morning and twilight of evening; it disperses and refracts their various tints to beautify the approach and the retreat of the orb of day. But for the atmosphere, sunshine would burst on us in a moment and fail us in the twinkling of an eye—removing us in an instant from midnight darkness to the blaze of noon. We should have no twilight to soften and beautify the landscape, no clouds to shade us from the scorching heat; but the bald earth, as it revolved on its axis, would turn its tanned and weakened front to the full and unmitigated rays of the lord of day.

"The atmosphere affords the gas which vivifies and warms our frames; it receives into itself that which has been polluted by use, and is thrown off as noxious. It feeds the flame of life exactly as it does that of the fire. It is in both cases consumed, in both cases it affords the food of consumption, and in both cases it becomes combined with charcoal, which requires it for combustion, and which removes it when combustion is over. It is the girdling encircling air that makes the whole world kin. The carbonic acid with which to-day our breathing fills the air, to-morrow seeks its way round the world. The date-trees that grow round the falls of the Nile will drink it in by their leaves; the cedars of Lebanon will take of it to add to their stature; the cocoa-nuts of Tahiti will grow rapidly upon it; and the palms and bananas of Japan will change it into flowers. The oxygen we are breathing was distilled for us some short time ago by the magnolias of the Susquehanna and the great trees that skirt the Amazon and the Orinocco; the great rhododendrons of the Himalayas contributed to it; and the roses and myrtles of Cashmere, the cinnamon-tree of Ceylon, and the forest, older than the Flood, that lies buried deep in the heart of Africa, far beyond the Mountains of the Moon, gave it out. The rain we see descending was thawed for us out of the icebergs which have watched the polar star for ages, or it came from snows that rested on the summits of the Alps, but which the lotus-lilies have soaked up from the Nile, and exhaled as vapour again into the ever-present air."]

203. Had the globe presented either one uniform surface of land or one uniform surface of water to the sun's rays, the interchanges of heat and moisture between the colder and warmer, the drier and moister regions of the atmosphere, would have been regular and continuous. But the earth's surface being composed of land and water in unequal proportions, and this land lying not only in irregular masses but presenting also irregular surfaces of highland and lowland, the movements of the atmosphere are so broken up and complicated that the winds and rains, the heat and cold, are rendered extremely variable—so variable, indeed, that Meteorology consists as yet more of collections of facts and approximations to results than of ascertained and definable laws. Under these circumstances we shall glance merely at the leading features of the atmosphere—its heat, moisture, and motions—as bearing more directly on the *climate*, or weather-conditions, if we may so express it, of the earth's various regions.

Its Heat and Moisture.

204. In dealing with the subject of climate, the superficial or atmospheric temperature of the globe may be viewed as wholly

dependent on the heat of the sun—the amount conveyed from within (paragraph 18) or radiated from the moon and other external sources being by far too feeble to have any perceptible influence. As is well known, the solar rays exercise the greatest effect within the tropics, where they fall vertically or nearly so on the earth's surface, and that this effect gradually declines as we proceed through the temperate zones towards either pole. In other words, the higher the angle at which the sun's rays strike the earth the greater their heating power, and the lower the angle the less the amount of heat imparted. We feel the truth of this every summer-day, when the sun is high a-head during the scorching noontide, and when his beams fall at a lower angle during the cooler afternoon. At whatever inclination they fall, there is always, as before explained, a certain amount of heat lost or extinguished in passing through the atmosphere; and this amount for nearly vertical incidence within the tropics has been estimated at one-third; for inclinations of less than 25 degrees at fully one-half; while at inclinations of 5 degrees scarcely one-twentieth of the solar heat is supposed to reach the surface. In this way 23° 44′ 40″ on either side of the equator forms a belt within which the solar heat received is equal to what is received by all the rest of the world; hence the student will perceive the applicability of the terms "torrid," "temperate," and "frigid" zones. Keeping out of view all minor modifications produced by the peculiar disposition of sea and land, as well as by the sun's alternate passage to the northern and southern hemisphere along the course of the ecliptic, it may be received as the first great axiom, that the superficial temperature of the globe is highest under the vertical incidence of the sun's rays near the equator; and that it gradually becomes lower and lower as we proceed towards either pole, and this in proportion to the obliquity at which the heat-giving rays fall upon the surface.

205. The heat that falls on the land being partly absorbed and partly radiated into the atmosphere, the lower aërial strata, or those nearest the influence of this radiation, will be warmer than those at higher elevations. The rate at which this diminution takes place depends, as has been shown by Mr Glaisher's balloon ascents in 1863, on many correlative circumstances — dryness, moisture, currents, &c.; but as an approximative rule, the decrease may be reckoned as equal to 1° of Fahr. for every 300 or 350 feet of ascent. In this way the lower plains of a region may be teeming with vegetation while the higher mountains are enveloped in perpetual snow. We have thus two great causes affecting the superficial temperature of the globe—distance from the

equator, and elevation above the level of the sea; so that at any given latitude it is much the same whether we travel towards the nearer pole or ascend a lofty mountain. In both we will meet with a gradually decreasing temperature, in both we will meet with a similar change in animal and vegetable life, and in both we will ultimately reach a limit of perpetual ice and snow. In the case of elevation, this limit is known as the *snow-line*, at which the air in summer attains the temperature of freezing water; and though slightly modified by surrounding circumstances, it varies primarily with the latitude—ascending from 2000 feet within the polar circle to 15,000 or 16,000 feet in the vicinity of the equator. In the case of horizontal extension, *the line of constantly frozen ground* differs in either hemisphere—that in the northern (see Map of Isotherms) assuming an irregular course, in consequence of the unequal distribution of sea and land, and that of the southern being less determinable in consequence of the greater expanse of Antarctic Ocean.

["One of the principal subjects of research in the balloon experiments of 1862," says Mr Glaisher, "was the determination of the law of decrease of temperature with increase of elevation. It is a subject to which very great interest is attached, and to the determination of which a great deal of labour and research has been devoted, resulting in the adoption of the theory of a uniform rate of decrease of 1° of Fahr. for every increase of 300 feet. The results from my several ascents were that, when the sky was clear, a decline of 1° took place within 100 feet of the earth, while at the height of 30,000 feet a space of fully 1000 feet had to be passed for a change of 1° of temperature; and that between these limits a gradually increasing space was required for a change of temperature to the same amount, plainly indicating that the theory of a decline of 1° of temperature for every 300 feet of elevation must be abandoned. The previous eight balloon ascents were made in the months of July, August, and September. It became of the highest importance to have similar experiments in the other months of the year; and the British Association, at its meeting in Cambridge, voted £200 for further experiments to be begun in the spring, and some of these, if possible, during the prevalence of the east wind. The first of these ascents took place in March 1863 from the grounds of the Crystal Palace. The balloon left the earth at 4h. 16m. P.M., the temperature of the air being 50°. At 4h. 25m. we were one mile high, with a temperature of 33½°; the second mile was reached at 4h. 35m., with a temperature of 26°; the third mile at 4h. 44m., when the temperature was 14°; and at 3¾ miles high the temperature was 8°. A warm current of air was met with, and the temperature rose to 12° at 4h. 58m.; at 5h. 2m. we passed out of this current, and when 4½ miles high the temperature was just zero of Fahrenheit's scale. In descending the temperature increased to 11° at about three miles high, at 5h. 38m.; then a cold current was met with, and it decreased to 7°. We soon passed through it, and the temperature increased to 18½° at two miles high to 25½° at one mile, and to 42° on the ground, which was reached at 6h. 30m. The air was dry before leaving the earth; it became very dry at heights exceeding two miles; and at heights exceeding four miles the temperature of the dew-point was fully *minus* 40°."]

206. Another cause of variation in atmospheric temperature is

the unequal reception and radiation of the sun's heat by the respective surfaces of land and water. The heat falling on the land is partly absorbed and conducted downwards into the soil, and partly radiated into the atmosphere. The amount absorbed will differ according to the colour, slope, and character of the land (dry, firm, and dark-coloured soils being most favourable for absorption); and according also as it is naked or shut out from the sun's rays by a covering of vegetation. The amount radiated differs with almost every passing condition of the atmosphere—radiation going rapidly forward under a still, clear sky, while a cloudy atmosphere, or even a passing mist, serves to retard it. The greater quantity of heat absorbed by day is given off by night; and the amount accumulated during summer is returned to the atmosphere during winter. The depth thus affected by summer's heat or winter's cold will differ according to latitude, soil, and situation,—the soil in Siberia, for example, being never thawed beyond the depth of a few feet, while under the equator the sun's influence has been known to extend to the limit of 90; but, on the whole, it may be safely asserted that beyond 60 or 80 feet the temperature of the earth's crust is little or at all affected by external influences. Indeed, for all practical purposes the superficial temperature of the land, as affecting climate, may be regarded as confined to a very few feet beneath the surface—the slow conducting power of the soil and capillary attraction of moisture from below combining to limit its downward tendency.

207. On the other hand, the heat that falls on the water is much more readily absorbed, but more slowly radiated, so that, being diffused by waves and currents, it penetrates to a considerable depth, and accumulates within the mass of the ocean. The heat that falls on any zone of the land is absorbed and radiated wholly within that zone; whereas that falling on any zone of the ocean is diffused and interchanged between every other zone. As the ocean radiates its heat more slowly than the land, and exposes more than thrice the surface to the sun's rays, it becomes, as it were, a great storehouse of heat for the exigencies of the land. It is for this reason that islands and seaboards possess a milder and more equable climate than the interior of continents—being warmer during winter and cooler during summer. The British Isles, with their comparatively cool summers and mild variable winters, are thus said to possess an *insular climate;* while the interior of Germany, with its excessively hot summers and cold winters, is said, on the contrary, to possess a *continental climate.* In tropical latitudes, unaffected, of course, by winter, the interior of continents is always much warmer than the sea-coasts and

adjacent islands. It is also for this reason that the northern and southern hemispheres, having unequal distributions of sea and land, are differently affected in their zones of climate—the greater extent of land in the northern imparting to it, as it were, a continental climate; while the greater expanse of ocean in the southern confers on its similar latitudes more of an insular climate. It is, further, to this unequal reception of heat by land and water that we owe the phenomena of sea and land breezes. During day the atmosphere immediately above the land is more rapidly heated by radiation than that above the ocean, hence the cooler sea-breeze sets in towards the land to restore the balance; while during the absence of the sun the more rapidly cooled land-atmosphere sets out as a land-breeze towards the more slowly cooling surface of the ocean. In fine, it is mainly owing to the unequal distribution of sea and land, and to the different modes in which the two elements are affected by the sun's heat, that we owe the great essentials of climatic diversity—the air and ocean-currents, the vapours and rains, of one region, varying from the winds, currents, and moisture of another.

208. Whatever the temperature of the air, it is incessantly receiving *moisture* from the surface of the land and water. This vapour arises and is diffused through its mass in an invisible form, and becomes visible only when condensed into mists, fogs, rains, and snows. It arises alike from land and water, but most copiously and persistently, of course, from the surface of the water. The superficial moisture of the land, unless where clothed with vegetation, is rapidly converted into vapour; but the supply from this source is irregular and limited compared with that derived from the water. Surface for surface, salt water is less vaporisable than fresh; hence a slight check to evaporation from the vast and extended surface of the ocean. It arises from rivers, lakes, and seas in every latitude, but most abundantly, of course, within the tropics, where the sun's heat is the greatest. So great is the evaporation within that zone, that it has been estimated as annually sufficient to reduce the surface of the sea to a depth of 8 or 10 feet—a waste, of course, that is incessantly counterbalanced by influx from other latitudes. The warmer the air the greater its capacity for moisture; and this capacity for holding moisture in suspension increases up to the point of saturation, when any reduction in temperature produces condensation, and rain ensues.

209. As in the case of other meteorological phenomena, the circumstances connected with the production and retention of atmospheric vapour are extremely complicated: but in general terms

it may be stated that heat is the grand promoter of evaporation; that a gentle current of air, by removing the pressure of the vapour as it is formed, is more favourable than a stagnant atmosphere; and that it is retarded by moist and cloudy conditions of the air, even though the sensation of heat be considerable. As previously mentioned, the humidity of the atmosphere is confined chiefly to its lower strata; and so rapidly does the quantity diminish as we ascend, that at the height of five or six miles it becomes all but inappreciable. The quantity of moisture evaporated from the surface of the globe may differ from day to day, and from year to year; but on the whole, and for any given number of years, it is returned again in the state of dew, rain, hail, or snow. Understanding the general conditions of the atmosphere as regards its heat and moisture, we may now proceed to its special effects in the production of winds, rains, and other kindred phenomena.

Winds—Constant, Periodical, and Variable.

210. As already explained, any current of the atmosphere produced by inequality of temperature or density is termed a *wind* —the denser and colder air rushing in to supply the place of the lighter and warmer. In other words, *wind is air in motion;* and the most frequent cause of such motion is disparity of temperature between adjacent districts. As inequality of temperature is ever arising alike from general and from local causes, the occurrence of winds is incessant and universal, either along the earth's surface, or in the higher strata of the atmosphere. While the colder current is flowing *below* from the colder to the warmer region, a warm current is floating *above* from the warmer to the colder. As the homogeneity of the ocean is maintained by its currents, so the equilibrium and uniformity of the atmosphere is preserved by its winds. These winds, having different times, directions, and characters, are necessarily arranged into different classes, and distinguished by various designations.

211. As regards times, those blowing constantly in one direction between, and within a few degrees beyond, the tropics (the Trades), are spoken of as *permanent winds;* those blowing at certain periods (the Monsoons, &c.), as *periodical;* and those obeying no fixed period, as *variable.* As concerns direction, they are distinguished by the points of the compass, as North, South, East, West, South-west, South-south-west, &c., according to the quarter from which they blow. And as regards inherent or cli-

matic character, they are cold or hot, dry or moist, gentle or boisterous, healthful or unhealthful, according to locality and other accompanying conditions. One of the most obvious characteristics of winds is their velocity, which may vary from a few miles to upwards of a hundred miles an hour; and between these extreme rates we have every variety, from the gentlest zephyr to the most violent hurricane. According to meteorological authorities, a velocity of 7 miles per hour is regarded as a gentle air; of 14, as a light breeze; of 21, a good sailing breeze; of 41, a gale; of 61, a great storm; of 82, a tempest; and of 92, a hurricane, producing universal devastation—tearing up trees and sweeping away buildings. Or more minutely, according to their *velocity* and *force*, they have been arranged as follows:—

Velocity in Miles per Hour.	Force in lb. Avoird. per Square Foot.	Common Appellation.
1	.005	Breath of air.
4	.079	Gentle air.
5	.123	Light wind.
10	.492	Brisk wind.
15	1.107	Light breeze.
20	1.968	Brisk breeze.
25	3.075	Stiff breeze.
30	4.429	High wind.
35	6.027	Gale.
40	7.873	Strong gale.
50	12.300	Storm.
60	17.715	Great storm.
80	31.490	Hurricane or tempest.
100	49.200	Violent hurricane.

212. In whatever character they occur, winds are important agents in the production and modification of climate. By their agency the moist and heated atmosphere of one region is transferred to another; and on their agency also depend, in a great measure, those currents of the ocean which are ever producing interchanges between the colder and warmer surface-waters of different latitudes. Besides these great climatological functions, they are intimately concerned in the production of rains and other aqueous phenomena; while their incessant commotions tend to preserve the atmosphere in ever-healthful equilibrium. They are the great bond, as has been well observed, between the land and water surfaces—transferring the moisture of the one to the thirsty uplands of the other, and the dry cold air of the former to disperse and rarefy the humid and depressing atmosphere of the latter. Geologically, winds have considerable effect in removing, piling

up, and re-assorting all loose superficial matters, as the sand-dunes of the sea-shore and the sand-drift of the desert; while through the agency of the ocean-waves, which are created by their power, important changes are produced along every shore of the world. In their gentler manifestations they assist in the fertilisation of plants and in the dispersion of their seeds; while in their fiercer demonstrations their track is marked by ruin and devastation. By their impulse the commerce of distant nations is wafted from shore to shore; and fickle and fitful as they may appear, man not unfrequently avails himself of their power to turn the wheels and shafts of his machinery.

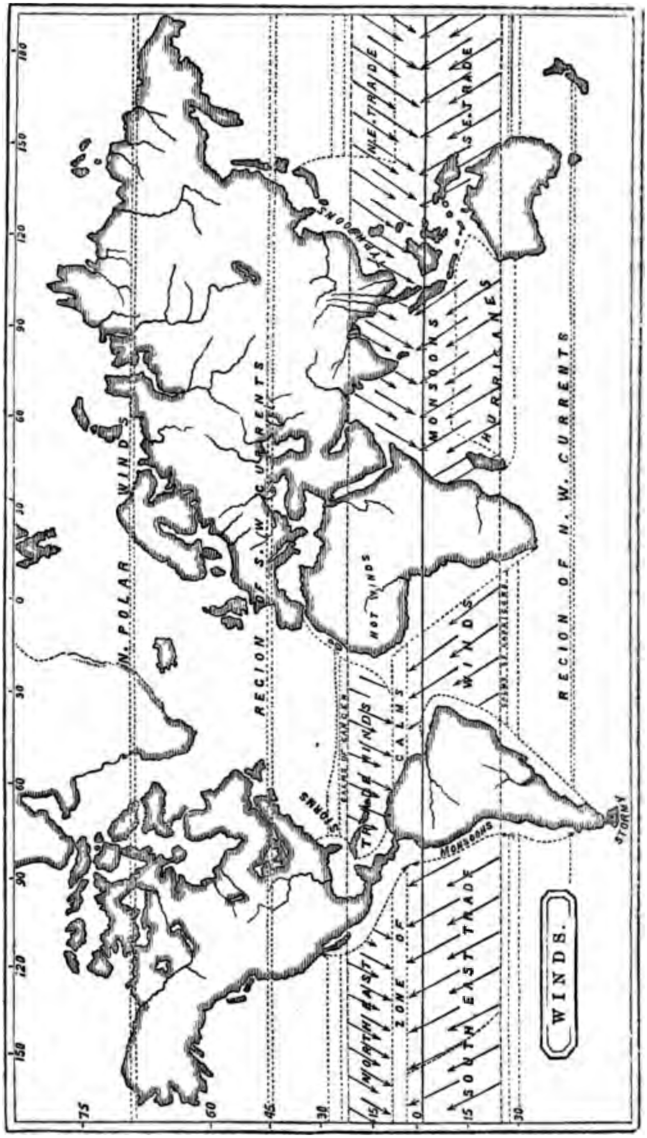
213. The most remarkable of the *permanent, constant*, or *perennial* air-currents are the TRADE WINDS (so called from their influence on the trade or commerce of the world), which, within the torrid zone and a few degrees beyond it on either side, are ever sweeping round the globe in a westerly direction. This is occasioned by the fact that the region near the equator is most intensely heated — the other zones becoming colder and colder towards either pole. Under these circumstances, the air of the torrid zone becomes rarefied and ascends, while the colder and denser air sets in from either side to supply the deficiency. There are thus generated two great sets of currents—colder under-currents setting in towards the equator respectively from the north and south, and warm upper-currents flowing off from the equator towards either pole. If, then, the atmosphere were subject to no other influence than temperature, a *north wind* would always prevail along the earth's surface in the *northern hemisphere*, and a *south wind* in the *southern hemisphere*. But as the polar currents proceed towards the equator, they gradually come into zones having a greater velocity of rotation, and thus they are deflected in a westerly direction (as exhibited in the accompanying Sketch-Map), so as to become a *north-east* wind in the northern hemisphere, and a *south-east* wind in the southern.

214. In the Pacific, the north-east trade-wind may be said to prevail between the 25th and 2d degree of N. latitude; while the south-east trade ranges more widely between the 10th and 21st of S. latitude. In the Atlantic, on the other hand, the former is comprised between the 30th and 8th degree of N. latitude, and the latter, within the 3d of N. and the 28th of S. latitude. These limits, however, are not altogether stationary, but depend on the seasons—advancing towards the north during the summer of the northern hemisphere, and receding to the south as the sun withdraws to the southern tropic. Within these somewhat fluctuating zones, the trade-winds are steady and perennial, travelling

at the rate of from ten to twenty miles an hour, and wafting onwards in safety the merchandise of the globe. As they approach the continents, their courses become interrupted in consequence of the unequal heating of the land and water surfaces; hence within these coast-areas they assume the character of periodical, rather than of constant currents, being deflected at certain seasons from their normal directions.

215. As the north-east and south-east trades approach the equator of temperature, their currents begin to fail, and this effect, augmented by the upward tendency of the highly heated air of that region, produces a zone or belt of calms, which fluctuates a few degrees north and south, according to the seasons. If the approaching trades be equally reduced in any locality, a dead calm will be the result; but as this is seldom the case, the zone is also characterised by short gusty winds, which vary in force and direction according as either main current prevails. This *zone of calms and variables*, as it is termed, is further characterised by the frequency and intensity of its thunder-storms—the crossing and collision of currents of unequal densities being favourable to the manifestation of electrical phenomena. In the Atlantic, the region of calms (see Sketch-Map) ranges in August between 3° and 12° N. lat.; but in February it extends from 1° 15′ to 6° N. lat. A portion of this zone near the Cape Verde Isles is known to sailors as the "rainy sea;" and is described as "a region doomed to continual calms, broken up only by terrific storms of thunder and lightning, accompanied by torrents of rain. A suffocating heat prevails, and the torpid atmosphere is disturbed at intervals by short and sudden gusts, of little extent and power, which blow from every quarter of the heavens in the space of an hour—each dying away ere it is succeeded by another. In these latitudes vessels are sometimes detained for weeks." In the Pacific, the region of calms is comprised within the 2d degree of north and south latitude, near Cape Francis and the Galapagos Islands—a narrow belt separating the two trades, and characterised by the same phenomena as the calm zone of the Atlantic.

216. Besides the trade-winds, which are the most persistent of all aërial currents, there are certain winds in the higher latitudes that also blow with considerable continuity. The heated air which ascends from the tropics, and flows off towards either pole, gradually descends as it proceeds; but as it passes from latitudes having a high to others having a less rotatory velocity, it is deflected from its original course, and assumes a south-easterly direction in the northern hemisphere, and a north-easterly in the southern. In this way the prevailing winds in the higher latitudes


WINDS.
N. POLAR WINDS
REGION OF S. W. CURRENTS
REGION OF N. W. CURRENTS
N.E. TRADE
S.E. TRADE
MONSOONS
HURRICANES
TYPHOONS
HOT WINDS
WINDS
STORMS
CALMS
TRADE WINDS
NORTH EAST
ZONE OF
SOUTH EAST TRADE
MONSOONS
STORMY

of the northern hemisphere are from the *south-west*, and those in the southern hemisphere from the *north-west;* and though many causes—unequal distribution of sea and land, position of continents, irregularity of land-surface, &c.—tend to disturb this continuity, still, on the whole, there is a marked predominance of westerly winds. In our own islands, the fact must be sufficiently obvious to every observer; in the North Atlantic, the average packet-voyage from New York to Liverpool is 23 days, while the return voyage requires 40 days; and in the vicinity of Cape Horn, westerly winds are three times more frequent than those from an easterly direction.

217. Among the constant currents of the atmosphere must also be enumerated the *north and south polar winds*, which, as mentioned in the theory of the trade-winds, are continually flowing north and south from either pole. And further, as an undercurrent almost invariably implies the existence of an upper current in a contrary direction, we may notice also the *upper west wind of the tropics*, which, high above the trades, seems constantly flowing in an opposite direction. Proofs of this upper tropical wind are found in the circumstance that dust ejected from the volcanoes of the West Indies has fallen on ship-deck several hundred miles to the eastward; and also in the often-observed fact, that a similar wind prevails near the summit of Teneriffe (12,000 ft.), while the regular trade-wind is blowing from an opposite direction below.

["The existence of the upper trade-wind, coming from the west, or of the return trade-wind, which has often been doubted, seems to be proved in the Atlantic," says M. Guyot, "by two facts often cited and very conclusive. The volcano of the island of St Vincent, belonging to the Lesser Antilles, in one of its eruptions hurled a column of volcanic cinders to a great height in the atmosphere; the inhabitants of Barbadoes, situated east of St Vincent, saw with astonishment the cinders falling upon their island. The 25th of February 1835, the volcano of Cosiguina, in Guatemala, threw into the air such a quantity of cinders that the light of the sun was darkened during five days; a few days after, they were seen to cover the streets of Kingston, in Jamaica, situated north-east of Guatemala. In these two cases it is evident that the cinders had reached the region of the upper trade-wind, and had been carried by it from west to east, in the opposite direction to the lower trade-wind. At the summit of the peak of Teneriffe, most travellers have found a west wind, even when the north-east trade-wind prevailed on the seaboard."]

218. Of the *periodical winds* the most important are the MONSOONS (from the Malay word *moussin*, signifying seasons), which in certain countries within and near the tropics blow from a certain quarter for one-half the year, and from an opposite point during the other half—the period of change being marked by calms, tempests, and variables. In other words, the monsoons are but the trade-winds interrupted in their regular action by the

geographical peculiarities of the regions in which they occur. From April to October, the *south-west* monsoon prevails north of the equator, and the *south-east* in the southern hemisphere; but from October to April the *north-west* monsoon blows south of the equator, and the *north-east* in the northern hemisphere. Of course, the farther from the equator, the later in the season will the south-west and north-west monsoons occur; and thus it happens that in India, at Anjengo, on the Malabar coast, 8° 30′ N. lat., the south-west monsoon commences as early as the 8th of April; at Bombay, 10° N. lat., about the 15th of May; in Arabia it commences a month earlier than on the coast of Africa; and in the northern part of Ceylon, fifteen or twenty days earlier than on the coast of Coromandel.

219. The cause of the monsoons is to be sought in the effect produced by the sun during his apparent annual progress from one tropic to the other, and has been thus explained:—"In the Indian Ocean, for example, as the sun advances towards the north, the zone of greatest rarefaction recedes from the equator, and the north-east monsoon (which is nothing more than the trade-wind) then subsides, and is succeeded by calms and variable winds; but as the summer approaches, and the sun arrives at the northern tropic, the southern portions of the Asiatic continent become hotter than the ocean, and the humid air from the equatorial seas flows northward to the land; south-west winds will therefore arise, which prevail from the peninsula of India to the Arabian Gulf, until the time of the autumnal equinox. During the same period the south-east monsoon, in the southern hemisphere, tempers the heat of Lower Guinea, and brings rain to the shores of Brazil. The motions of the atmosphere, however, are *reversed* as the sun crosses the equator and approaches the southern tropic. Pouring his fervid rays upon Southern Africa, the vast tract of New Holland, and the splendid clime of Brazil, the air flows in from the north and north-west towards these highly heated regions, and winds from these quarters prevail for several months—the monsoon extending along the coast of Brazil from Cape St Augustine to the Isle of St Catherine. But now the influence of the sun is partially withdrawn from Southern Asia; it glows no longer beneath its vertical rays, and over the cooled earth the north-east monsoon resumes its wonted course."

220. Equally remarkable for their persistency, though local in their areas and limited in their times, are the *land and sea breezes*, which occur on almost every seaboard, but most notably, of course, within the tropics. As formerly explained, these breezes arise from the unequal heating of the land and water surfaces, and be-

come most decided where this inequality is greatest. During day the land-surface, from its low conducting power, acquires a more elevated temperature than the adjacent waters, and the air above it, partaking of this heat, becomes rarefied and ascends, while the cooler and denser air from the ocean sets in as a *sea-breeze* to restore the equilibrium. This sea-breeze, especially in tropical latitudes, commences about nine in the morning, gradually increases in force till the middle of the day, and falls away as the sun declines in the afternoon. As evening approaches, the air over the surface of the land becomes more rapidly cooled by radiation than that over the water, and then a cool *land-breeze* sets out towards the ocean, blows freshly during the night, and dies away towards morning, when the sea-breeze again commences. The extent of these breezes is exceedingly variable. In some localities they blow only for a few miles out and in of the shoreline, while in others their bracing and refreshing influence is experienced for many leagues in either direction.

221. Owing to the mobility of the atmosphere, and the many causes that may temporarily affect its temperature and density, the *variable winds* are exceedingly numerous and capricious—so capricious, that "fickle as the wind" has become an established simile in every extra-tropical country. We say *extra-tropical*, for within the tropics the trades and monsoons are the prevalent winds, and these, as we have seen, maintain a remarkable degree of permanency and periodicity. But in extra-tropical regions, where the force of the permanent winds becomes feeble, a thousand causes (as unequal distribution of land and water, nature of soil, irregularity of surface, &c.) occur to disturb these currents, and thus almost every district has its temporary winds—varying in direction, force, and duration. Fickle and uncertain as they may appear, they are, nevertheless, the results of law and law-directed forces; but these forces being so complicated, comparatively little has been determined in this department of meteorology. Still, we know that in the middle latitudes of the northern hemisphere there are, properly speaking, only two normal winds—that of the north-east, and that of the south-west—the former being the cold polar hurrying towards the equator, and the latter the warm equatorial trending towards the poles. "The winds blowing in other directions are local winds, or transition winds, from one of the general currents to the other; and Professor Dove has shown that in Europe, at least, these winds succeed each other in an order always the same, which he has called the law of rotation of the winds. This will be easily under-

stood if we remember that in advancing along their course the south-west tends always to become more west, and the north-east more and more east; we shall see that the result of this disposition ought to be, whenever they meet and change places, a rotation from west by north to east, and from east by south to west. In the place of the conflict of the two currents, the wind will then blow successively from three different regions, and in this order, until it is established in the direction of that one of the currents which has overpowered the other. But no one of these transition winds blows for any great length of time. In the southern hemisphere the order of succession is the reverse."

[Referring to the winds of the northern hemisphere, the eloquent author of 'Earth and Man' has the following suggestive remarks:—"This conflict of polar and equatorial winds, opposite in character and direction, gives to our climate one of its most characteristic features, that changeableness, that extreme variety of temperature, of dryness, and of moisture, of fair weather and of foul, that uncertainty of the seasons, which always keep the merchant and the farmer in anxious suspense, between the hope of a good harvest and the fear of a dearth. Not only are the variations in the same year considerable, but they are still more so from one year to another. The system of these currents oscillates from east to west, and changes place. The polar winds will prevail in a country, and will endanger the crops by the prolonged dryness of their atmosphere; while further east or west the trade-wind will spread fertility by its beneficent rains. Or the opposite: the south winds acquire such a preponderance, that the harvests perish by the moisture; while, at a somewhat greater distance, on the limit of the same wind, Nature lavishes all her treasures upon the labourer. It has been remarked that a mild winter in Europe corresponds frequently to a severe winter in America and Asia; while the mildness of the winter in America affords a presumption of a colder winter on the other side of the Atlantic. The years 1816 and 1817 were marked, as is known, in the history of Europe, by a general famine and distress. The wet was such that the harvests failed entirely. But the south-west wind, which blew without cessation over the western part of the continent, and which drenched it in its vapours, did not extend beyond Poland; and it was the south of Russia whose corn supported famished Europe for many long months. Then was revealed the commercial importance of those countries, hitherto unknown, and constantly increasing since. Who does not still remember the immense impulse given to the commerce between Europe and America by the drought of 1846, which damaged the corn-crop in Europe while America had an abundant harvest? These examples alone tell us the important part played in the life of nations by those variations of the atmospheric currents belonging to our temperate countries."]

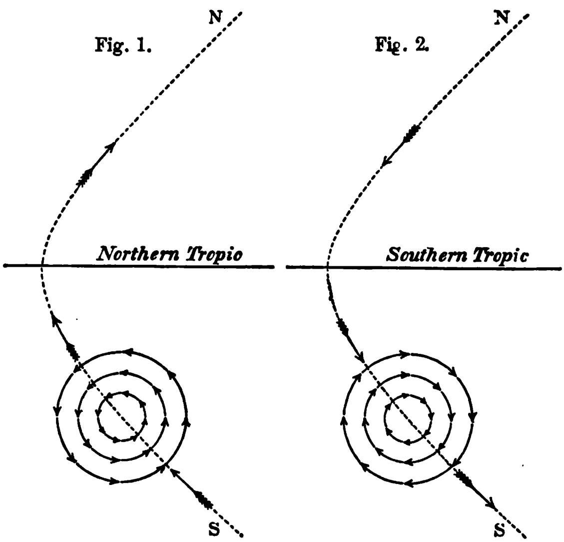
222. Generally speaking, in the higher latitudes of the northern hemisphere, a south wind is warm and moist, because it comes from warmer regions, and passes over a greater extent of ocean; while, on the contrary, and for opposite reasons, a north wind is cold and dry. It is for this reason that the westerly and south-westerly winds of Europe are humid and genial, and the north and north-easterly hard and ungenial. These major currents are of course much modified in their passage over certain localities, and

hence the various characteristics assigned to the *Etesian Winds* (Gr. *etesios*, annual) that prevail very much in early summer all over Europe. One of the most noticeable of local winds is the *Simoom* (Arabic, hot and poisonous)—a hot, suffocating blast that occurs in most countries bordering on sandy deserts, especially in certain parts of Asia and Africa, where its temperature has been noted as high as 120 and 130 degrees. Coming from the arid desert, and laden with the minutest particles, it often gives a reddish colour to the atmosphere, and thus forewarns the traveller to take shelter from the approach of its pestilential breath. In Turkey it is called the *Samieli;* in Egypt, *Khamsin* (fifty), because it usually continues fifty days; and in Guinea and Senegambia, *Harmattan.* The *Sirocco* (Arabic) is another hot, parching wind, that occasionally passes over Sicily and adjacent districts, and is supposed to originate in the Sahara, or great burning desert of Africa. The *Solano* (Lat. *sol*, the sun) is a similar south-west wind that occasionally visits the Spanish peninsula, and, blowing from the direction of the African deserts, is regarded as a modified sirocco.

223. In Buenos Ayres, *Pampero* is the name given to a violent west wind, which, traversing the arid plains of the Pampas, raises whirlwinds of dust, and carries them forward to the coast of the Atlantic. The pamperos seem to be portion of the return or north-west trade-winds. In Peru, between the Cordilleras and the Andes, at the height of 12,000 feet, are vast tracts of desolate table-land, known by the name of the *Puna.* These regions are swept for four months in the year by piercing cold winds (the *Puna Winds*) from the snowy peaks of the Cordilleras, which are so extremely dry, and absorb moisture with such rapidity in their passage, as even to prevent putrefaction in dead animal bodies.

224. Among the most remarkable of the variable winds are those familiarly known as *Whirlwinds*, and technically as *Tornadoes*, *Typhoons*, and *Cyclones.* Properly speaking, a whirlwind is an aërial current that assumes a rotatory, whirling, or spiral motion. *Whirlwinds* are often of great violence, but fortunately of short duration, and are most frequently caused by the meeting of contrary winds, though sometimes by obstructions of the land, as precipitous mountains, narrow gorges, and the like. Their occurrence at sea produces *waterspouts*, and on the sands of the desert *sand-pillars*, and kindred phenomena. *Tornadoes* (Span. *tournar*, to turn) are merely violent whirlwinds, though the term is usually applied to such as are accompanied by lightning, thunder, and rain. *Typhoons* (Gr.) are literally also tempests or whirlwinds; but the name is specially given by navigators to the hur-

ricanes that visit (generally from June to November) the seas of southern China, and the adjacent archipelago of the Philippine and Molucca islands. *Cyclone* (Gr. *kuklos*, a circle or whirl), on the other hand, is now the technical term applied by navigators to those rotatory hurricanes which occur most frequently between the equator and the tropics, and near the equatorial limit of the trade-winds. They sweep round and round with a progressive motion, their course describing a curve, and their violence being greater the narrower the limit of their whirl. In both hemispheres the rotation of a cyclone is *contrary* to that of the sun—those in the northern hemisphere moving counter, so to speak, to the motion of a watch-hand; those in the southern following that motion, as indicated in the following diagrams:—



1, General direction and rotation of Hurricanes in the Northern Hemisphere; 2, General direction and rotation of Hurricanes in the Southern Hemisphere.

225. The following succinct statement of the characteristics and general laws of cyclones may be found useful by way of reference:—1st. It has been fully ascertained that in both hemispheres the air in the cyclone rotates in a direction *contrary* to that of the sun. Thus in the northern hemisphere, the course of the sun being from east to south, west, and north, the course of the hurricane is

from north by west, south, and east; and in the southern hemisphere, the sun's course being east by north, west, and south, the hurricane runs from north by east, south, and west. 2d. They rotate in the space between the equator and the tropics, near the equatorial limit of the trade-winds. 3d. There is no instance on record of a hurricane having been encountered on the equator, nor of any one having crossed the line, though two have been known to be raging at the same time in the same meridian, but on opposite sides of the equator, and only 10° or 12° apart. 4th. Their movement, which is always oblique, from the equator to the poles, is usually from east to west at first, and towards the end west to east, which is but a development of the gyratory motion that forms their most essential characteristic. 5th. The motion of translation varies from so low as 9 miles an hour to 43 miles an hour. There is no precise estimate of the velocity of the gyratory motion. 6th. They are liable to dilate and contract in area, the contraction always implying a great accession of violence.

XII.

THE ATMOSPHERE—CLIMATOLOGY.

Dew, Rain, Hail, Snow, &c.

226. CLOSELY connected with the winds, and greatly influenced in their character by them, are the dews, rains, snows, and other aqueous phenomena which enter so largely into the determination of climate. The consideration of these subjects belongs especially to the province of Meteorology, but as much may be here recapitulated as will enable the student to trace their connection with the subject of Physical Geography. As already stated, insensible vapour to a greater or less amount is always present in the atmosphere as one of its accidental ingredients. The warmer the air the greater its capacity for this moisture; hence the greater amount taken up during the heat of the day. After sunset the earth and air lose their heat by radiation into space, but the former parts with it more rapidly; hence on its cooled surface the moisture in the air is condensed as *dew*—just as the outside of a cold-water bottle is bedimmed or *bedewed* with moisture on being brought into the warmer air of a sitting-room. Dew is, therefore, the moisture insensibly deposited from the atmosphere on the surface of the earth; and what is termed the *dew-point* is that temperature of the atmosphere at which it begins to be precipitated. The quantity of dew deposited during any night may be ascertained by a *drosometer* (Gr., dew-measurer); and perhaps the most simple process is to expose to the open air bodies like locks of wool, whose exact weight is known, and then to weigh them afresh after they are covered with dew.

227. Dew never begins to be deposited upon the surface of any body until it is colder than the contiguous atmosphere; and the quantity deposited depends chiefly upon the humidity, serenity, and tranquillity of the atmosphere, as well as on the constitution, surface, and locality of the bodies receiving the moisture. Still, clear nights are, therefore, more favourable for the deposition of

dew than windy and cloudy ones; and all substances like glass, silk, wool, grass, &c., which rapidly lose their own heat and slowly acquire that of others (that is, good radiators but bad conductors), are susceptible of being copiously bedewed; while substances like rocks and metals, which possess opposite qualities, contract but little dew. Bodies freely exposed to the atmosphere are more rapidly bedewed than those in any way screened or sheltered: and those near the soil more copiously wetted than such as are placed only a few inches higher. It is thus that the grassy turf is often pearled with dew while the taller herbage is comparatively dry; and the open country refreshed when the fall within towns is imperceptible. In temperate zones, where the frequent interchange of sun and shower preserves the earth from the extremes of heat and moisture, very little dew is deposited; but in tropical regions, where the day-heat is excessive, and no rain falls for months, the dews are most abundant and refreshing. But for this beneficent arrangement many intertropical countries would be altogether sterile and barren of vegetation. It must be remembered, however, that over arid deserts, where the air is excessively dry, there will be little or no dewfall, no matter what the intensity of nocturnal radiation. And in contrast to this it may be noticed that (all other things being equal) the most abundant dews occur in the neighbourhood of coasts, lakes, and rivers, where the atmosphere is in general more highly charged with moisture.

228. When the temperature of the air is reduced below that of the invisible vapour it contains, the moisture becomes visible, and appears as *fogs, mists,* and other kindred phenomena. These fogs occur most abundantly along the courses of rivers, on mountain-sides, over shoals and banks at sea, and generally along the sea-boards of continents and islands; and this obviously in consequence of the unequal temperature of the contiguous lands and waters. "In countries," says Kaemtz, "where the soil is moist and hot, and the air moist and cold, thick and frequent fogs may be expected. This is the case in England, the coasts of which are washed by a sea at an elevated temperature. The same is the case with the polar seas of Newfoundland, where the Gulf Stream, which comes from the south, has a higher temperature than that of the air." Like dews and rains, fogs exercise a refreshing influence on vegetation; and in some countries, like Peru, their occurrence is periodical and regular. *Clouds* have been defined as "masses of visible aqueous vapour which float in the sky, or drift through it with the wind, assuming every variety of colour and form." As clouds, they exercise but an indirect effect on terrestrial climate; and it is only when they break, by further condensation, into rain,

snow, and hail, that they come directly within the province of the geographer.

["Meteorologists distinguish, according to form, and consequently physical characters, three *primary* sorts of clouds—the cirrus, cumulus, and stratus; and four *secondary* or transition sorts—the cirro-cumulus, cirro-stratus, cumulo-stratus, and nimbus. The *cirrus* or curl-cloud (the catstail of sailors) is composed of thin filaments, the association of which resembles curls of woolly hair, and at times a filmy texture of network. It is the highest of all clouds, resting all but motionless in the thin blue atmosphere; and is by some supposed to consist of frozen vapour or light flakes of snow. The *cumulus* or heap-cloud (the ball-of-cotton of sailors) is generally a spring or summer cloud, and presents itself in the form of rolling hemispherical masses resting on a horizontal base. Sometimes these hemispheres are built one upon the other, and form those great clouds which accumulate on the horizon, and resemble at a distance mountains covered with snow. The *stratus* or spread-cloud is a horizontal band, which forms at sunset and disappears at sunrise. Under the name of *cirro-cumulus* are designated those little rounded clouds which are often called woolly clouds; and when the sky is covered with them it is said to be *fleecy*. The *cirro-stratus* is composed of little bands of filaments, more compacted than those of the cirrus; for the sun has sometimes a difficulty in piercing them with his rays. These clouds form horizontal strata, which at the zenith seem composed of a great number of thin clouds; whilst at the horizon, where we see the vertical projection, a long and very narrow band is visible. When the cumulus clouds are heaped together, and become more dense, this species of cloud passes into the condition of *cumulo-stratus*, which often assumes at the horizon a black or bluish tint, and passes into the state of *nimbus*, or rain-cloud. The latter is distinguished by its uniform grey tint and its fringed edges; and the clouds of which it is composed are so compounded that it is impossible to distinguish them."]

229. The precipitation of water from the atmosphere in the form of *rain* depends chiefly on the further condensation of clouds and fogs by the commingling of colder and warmer currents. The capacity of air for moisture decreases at a faster rate than the temperature, and thus the mingling of two currents only slightly differing in temperature may so reduce this capacity, that heavy rainfalls will take place even where there is no great decrease in atmospheric warmth. Where the temperature of the air falls below the freezing-point (32° Fahr.), the atmospheric vapour may be converted into *snow;* or if rain has been already formed in the upper air, the drops in passing through strata beneath the freezing-point will be converted into *hail.* Rain, hail, and snow are thus to a certain extent convertible phenomena: hail occurring in all latitudes and climates; but snow only in the colder latitudes, and at elevations where the thermometer continues below 32°. Winds being the great natural agents by which the colder and warmer masses of the atmosphere are brought into combination, rains will occur most frequently where these currents are shifting and variable. Where the winds are constant and of equable temperature, rain seldom happens, unless at points

where these currents impinge on lofty mountains, and carry up the air of the sea and plains into the colder regions of the atmosphere. As the capacity of the air for moisture increases with the temperature, it must happen (other things being favourable) that the amount of rainfall is greater in warm than in cold latitudes, and greater also in low-lying than in elevated districts.

230. For the foregoing reasons the amount of rainfall is greatest within the tropics, and decreases as we advance north or south into higher latitudes. It is also greater at the sea-level and moderate elevations than it is on lofty table-lands and mountains. In like manner more rain descends upon the coasts than upon the central regions of a country—the humid air from the ocean gradually parting with its moisture as it is borne farther and farther inland. In Britain, for example, where the prevalent winds are from the Atlantic, the annual rainfall on the west coast is about 37 inches, while on the east side of the island it rarely exceeds 25 inches. It must be observed, however, that though the annual rainfall within the tropics is greater than in higher latitudes, the number of rainy days is fewest within the tropics, or where the winds are constant, and most numerous in the higher latitudes, where the winds are shifting and variable. Thus, between 12° and 43° N. lat., the number of rainy days is stated at 78; between 43° and 46°, 103; between 46° and 50°, 134; and between 50° and 60°, as many as 161. Of course, since the rainy days are fewer in low latitudes, and the annual amount of rainfall greater, the rains must be much more powerful—a fact sufficiently recorded by all travellers in tropical regions.

231. Understanding these principles, and bearing in mind what was stated regarding the constant, periodical, and variable winds, the student will readily perceive—1. Why heavy and frequent rainfalls should take place within the so-called zone of calms, where evaporation is excessive, and the air often gusty and variable; 2. Why rain should seldom fall at sea within the region of the steady and equable trade-winds; 3. Why the rains within the range of the monsoons should be periodical, and the year divided into two seasons, a wet and a dry; 4. Why the rains in the higher latitudes should occur at no fixed period, but be irregularly distributed throughout the year; 5. Why some regions, like the central deserts of Africa and Asia and the coasts of Peru, should be altogether rainless; and, 6. Why almost constant rains should occur in some countries, like Guiana; while in others showers of excessive violence should occasionally fall, adding to their annual rainfall as much in the space of a few hours as ordinarily happen during the course of many months.

232. As may be expected, the annual rainfall of these different regions will differ very widely; and will be attended, of course, by proportionate results—heavy falls being beneficial in hot countries (unless they occur with such violence as to denude the surface of its soil), and moderate supplies in temperate and milder zones. In the British Islands the annual fall (as ascertained by rain-gauge) ranges from 24 to 60 inches, or has an average of about 36 inches; while in tropical countries the mean is upwards of 200 inches. As much, however, as 229 inches has been noted in Dutch Guiana, 276 in Brazil, 302 at an elevation of 4200 feet in the Western Ghauts, south of Bombay; and in the Khasia Mountains, at the head of the river-flats or Jheels of Bengal, upwards of 600 inches, or 50 feet, have been registered by several observers. At the same place, Dr Hooker has recorded 30 inches in twenty-four hours; 21 inches have been noted at Cayenne during the same period; and 23 inches are not uncommon near Port Jackson in New South Wales.

[Referring to the excessive rainfall at Khasia, and its effects in carrying off the soil and denuding the surface, Dr Hooker, in his 'Himalayan Journal,' has the following instructive passage:—"The climate of Khasia is remarkable for the excessive rainfall. Attention was first drawn to this by Mr Yule, who stated that in the month of August 1841, 264 inches fell; and that during five successive days 30 inches fell in every twenty-four hours. Dr Thomson and I also recorded 30 inches in one day and night, and during the seven months of our stay upwards of 500 inches fell, so that the total annual fall perhaps greatly exceeded 600 inches, or 50 feet, which has been registered in succeeding years! From April 1849 to April 1850, 502 inches fell. This unparalleled amount is attributable to the abruptness of the mountains which face the Bay of Bengal, from which they are separated by 200 miles of jheels and sunderbunds. . . . The direct effect of this deluge is to raise the little streams about Churra 14 feet in as many hours, and to inundate the whole flat, from which, however, the natural drainage is so complete, as to render a tract, which in such a climate and latitude should be clothed in exuberant forest, so sterile, that no tree finds support, and there is no soil for cultivation of any kind, not even of rice; owing, however, to the hardness of the horizontally-stratified sandstone, the streams have not cut deep channels, nor have the cataracts worked far back into the cliffs. The limestone alone seems to suffer, and the turbid streams from it prove how rapidly it is becoming denuded. The great mounds of angular gravel on the Churra flat are perhaps the remains of a deposit, 50 feet thick, elsewhere washed away by these rains; and I have remarked traces of the same over many slopes of the hills around."]

233. Extending the facts alluded to in the preceding paragraphs, the rainfall of the globe may be arranged under three great heads—the periodical of the tropics; the variable of the higher latitudes; and the abnormal of certain districts where it occurs either in excess or is altogether absent. Within the tropics the rainy season commences at the shifting of the monsoons; and as this change is dependent upon the position of the

sun, it begins earlier in those regions that lie near the equator than in those more remote. In general terms, the rainy season in the northern half of the torrid zone may be said to commence with April and last till October, while the dry season extends from October till April. In the southern half this order is reversed—the dry season embracing from April till October, and the season of rain from October till April. In Africa, for instance, near the equator, the wet season begins in April and continues till October; while in Senegambia it does not commence till June, and then lasts till November. In India, on the Malabar coast, the rains commence early in May, but do not reach Delhi till near the end of June. In the New World, also, the rain falls at Panamá early in March, but it seldom appears in California before the middle of June.

234. Commenting on the periodicity of the dry and the rainy season within the tropics, M. Guyot makes the following lucid and graphic remarks:—"Whenever the trade-wind blows with its wonted regularity, the sky preserves a constant serenity, and a deep azure blue, especially when the sun is in the opposite hemisphere; the air is dry and the atmosphere cloudless. But in proportion as the sun approaches the zenith, the trade-wind grows irregular, the sky assumes a whitish tint, it becomes overcast, clouds appear, sudden showers accompanied by fierce storms ensue. They occur more and more frequently, and turn at length into floods of rain, inundating the earth with torrents of water. The air is at this time so damp that the inhabitants are in an incessant vapour-bath. The heat is heavy and stifling, the body becomes dull and enervated: this is the period of those endemical fevers that destroy so great a number of the settlers who have come from the temperate zones. But vegetation puts on a new freshness and vigour; the desert itself becomes animated, and is overspread for a few months with enchanting verdure which furnishes pasture to thousands of animals. Nevertheless, ere long, the sun in his annual progress advances to pour down his vertical rays upon other places; the rains diminish, the atmosphere becomes once more serene, the trade-wind resumes its regularity, and the heaven shuts its windows once again until the following season. Such is the normal course of the tropical rains. They fall everywhere during the passage of the sun through the zenith. The heat is then so violent that the ascending current neutralises the horizontal trade-wind. It hurries the vapours to the heights of the atmosphere and the upper limit of the trade-wind, where they are condensed and fall back in a deluge of rain."

235. Of course, within the tropics as elsewhere, the regularity

of the periodical rains is interrupted by the configuration of the land, mountain-chains, and similar causes; hence the peculiarities that mark the times as well as intensities of the wet and dry seasons of such areas as the east coast of Africa, the Red Sea, the Malabar coast, the Coromandel coast, and the coasts of Australia. On the Malabar coast, for example, the south-west monsoon (coming from the humid region of the equatorial ocean to supply the place of the highly rarefied air of the heated continent) is said to be "ushered in by terrific storms of thunder and lightning. The water pours down in torrents, and when the thunder has ceased, nothing is heard for several days but the rush of the descending rain, and the roar of the swelling streams. In a few days the storm ceases, and the earth, which before was withered by the glowing atmosphere of the dry season, is now, as if by magic, suddenly clothed with the richest verdure; the air above floats pure and balmy, and bright tropical clouds sail tranquilly through the sky. After this, the rains fall at intervals for the space of a month, when they again return with great violence. In July they attain their height, and from that time gradually subside until the end of September, when the season closes, as it began, in thunders and tempests." On the eastern, or Coromandel side, the order of things is reversed. The south-west monsoon, in passing over the Western Ghauts and the central table-land of the Deccan, parts with all its moisture, and reaches the eastern side as a hot, dry wind; and it is not till the north-east monsoon begins to prevail in October that the rainy season is experienced on the coast of Coromandel.

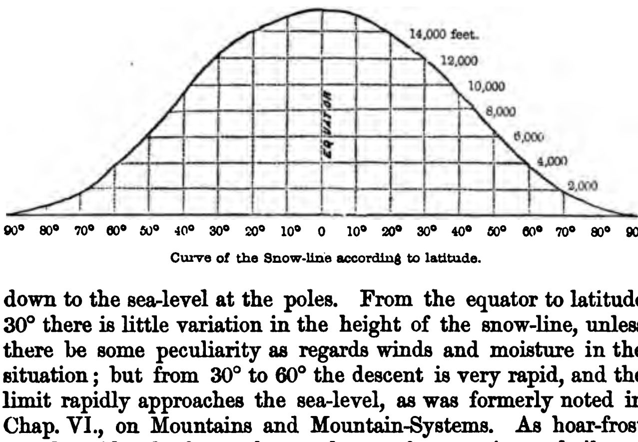
236. Beyond the tropics the rains no longer occur at stated periods, but become *variable*—that is, are distributed throughout the year in a very irregular and uncertain manner. In some countries they occur most frequently in winter; in some, in spring and autumn; and in others, again, most abundantly in summer. Thus, the amount that falls in the west of England in winter is said to be eight times greater than that in summer; in Germany the winter and summer amounts are about equal; but in St Petersburg the winter fall is little more than a third of what descends in summer. Again, in Britain, there are more rainy days in winter than in summer; but in Siberia it rains four times as often in summer as in winter. The countries of Europe bordering the Mediterranean are generally regions of winter rains; while those of western Europe are distinguished rather by the abundance of their autumnal rains. In Europe north of the Alps, the north-east winds (as coming from the higher and colder latitudes) are comparatively dry; while those from the south-west (from the humid expanse

of the Atlantic) are warm and laden with moisture. On the eastern coast of North America the reverse holds good, and the north-east winds borne from the ocean give rise to the long-continued rain-storms of spring and autumn.

237. As might be expected, the districts of *excessive rainfall* lie within the tropics, and mainly in the immediate neighbourhood of the equator. In the New World, Brazil, Guiana, the West India Islands, Central America, and the shores of the Mexican Gulf, are all notable for their heavy and continuous rains; while in the Old World, the coasts of Guinea and Senegambia, Eastern Africa, India, and the Indian Archipelago, are remarkable for similar phenomena. (See Rain Map in Atlas.) It must also be noted that in every latitude the rainfall becomes excessive in the neighbourhood of lofty mountains that lie in the course of moisture-laden winds. The average fall in the south of Europe may be about 36 inches, and yet at Tolmezzo in the Alps, where the moist south-west winds from the Mediterranean are condensed, the fall amounts to 90 inches! The summits of the Apennines receive 64 inches of rain, while the lowlands around receive an average of only 26; and while the Norwegian side of the Scandinavian chain, exposed to the moisture-laden winds of the Atlantic, receives as much as 82 inches of rain, the Swedish side experiences little more than 20! As some regions are celebrated for their rainy character, so others are equally remarkable for the entire absence of rainfall. Of these *rainless tracts* the more noted are the great desert lands of Africa, Arabia, Persia, and Mongolia —an almost continuous area, varying in breadth from the 15th to the 47th parallel, and in length from 16° west to 118° east longitude. Except on its borders this vast expanse is all but absolutely rainless, its heated atmosphere readily absorbing and converting into invisible vapour whatever humidity may be carried towards it from adjacent regions.

238. Of the other aqueous phenomena more immediately bearing on climate, the limits of a text-book will only permit the briefest allusion to hoar-frost, snow, hail, and those accumulations of frozen water known as glaciers and icebergs. *Hoar-frost* or *white-frost* is produced in the same manner as dew, and occurs chiefly in early spring and autumn, during serene nights, and when the surface of the earth falls below the freezing point. Whatever prevents the rapid radiation of heat (overhanging foliage, passing clouds and currents), arrests the formation of hoar-frost, which is often very destructive to tender plants and to buds and blossoms in early spring. *Snow* is the frozen moisture

that descends from the atmosphere when the temperature of the air at the surface of the earth is near or below the freezing point of water. Of course, at the sea-level within the tropics, and for fifteen or twenty degrees beyond them in either hemisphere, snow is unknown (see Rain and Snow Map in Atlas); and it is only during winter that it falls in the higher latitudes, and at considerable elevations. In the polar regions, and at extreme heights in all latitudes, it becomes perennial; and this limit at which it remains unaffected by the heat of summer is known as the *snow-line*, or, less accurately perhaps, as the line of *perpetual congelation*. The lower the latitude—that is, nearer the equator—the higher the snow-line, which descends constantly, but somewhat irregularly, according to the nature of the situation, as we proceed towards either pole. The following diagram will convey some idea of its gradual descent from 16,000 feet at the equator



Curve of the Snow-line according to latitude.

down to the sea-level at the poles. From the equator to latitude 30° there is little variation in the height of the snow-line, unless there be some peculiarity as regards winds and moisture in the situation; but from 30° to 60° the descent is very rapid, and the limit rapidly approaches the sea-level, as was formerly noted in Chap. VI., on Mountains and Mountain-Systems. As hoar-frost may be said to be frozen dew, and snow frozen mist, so *hail* may be described as frozen rain. It occurs in all latitudes and at all seasons; and though the producing causes are not always discernible, it seems mainly dependent on the meeting of aërial currents of greatly unequal temperatures, as well as on peculiar electrical conditions of the atmosphere. Falling in pellets from the size of a pea to that of a pigeon's egg, hail-storms are frequently very destructive, but luckily are always restricted to limited areas, and of short duration. *Sleet*, which is an admixture of snow and rain, or of small particles of hail and rain, generally occurs during squally weather in spring and autumn, and seems to fall from cloud-strata of different temperatures—the rain from one, and the hail or snow from another.

239. As snow must accumulate on all mountain-ridges above the snow-line, as well as on the surface of all polar lands within the limits of perpetually frozen ground, it will become more or less compressed, and this compression will be greatly augmented by its partial meltings in summer, as also by the falling and freezing of rain and other atmospheric vapours. From this accumulation, compression, and re-freezing, arise avalanches, glaciers, icebergs, and other kindred phenomena. *Avalanches* (Fr.) are accumulations of snow, or of snow and ice, which are frequently precipitated with destructive violence from lofty mountain-ridges, like those of the Alps, into the valleys and plains below. They originate on the higher slopes, and begin to descend when the weight of their mass becomes too great for the declivity on which it rests, or when fresh weather destroys its adhesion to the surface. *Glaciers*, on the other hand, are accumulations of ice, or of ice and snow, which collect in the valleys and ravines of snowy mountains like the Alps and Himalayas, or on boreal uplands like those of Greenland, and which move downwards (partly by their own gravity and partly by the expansion of the freezing water that falls into their crevices and fissures) with a peculiar creeping motion, smoothing the rocks over which they pass, and leaving mounds of debris (*moraines*), lateral and terminal, as they melt away. In mountain-gorges, glaciers descend as ice-streams till, coming below the snow-line, they begin to melt and disappear; but on polar lands, where they cover almost the entire surface, they move downwards to the sea-shore, and there, losing their support, the advancing fronts break off and are floated away as *icebergs* (ice-mountains) and ice-floes (ice-islands). The true mountain-glacier and lowland ice-mantle, though kindred phenomena, differ widely in their results—the former merely smoothing and grinding a course for itself in the mountain-gorge, the latter smoothing and rounding and striating the whole rock-surface of the country, and as it moves downward to the shore discharging its broken fringe of iceberg and debris forward into the ocean. Such ice-masses have been met in the Arctic and Antarctic Oceans several miles in circumference, rising from 40 to 200 feet above the water, and loaded with stones and shingle. Some idea of their size may be formed from the fact that little more than a tenth of their bulk rises above the water, the specific gravity of ice being only 0.9. As they are floated by the polar currents to warmer latitudes they melt away, dropping their burden of boulders and debris on the bottom of the ocean. "Fields" and "packs"

of such ice are familiar phenomena both in arctic and antarctic waters—the bergs of the north being seldom carried southward in the Atlantic beyond the 44th parallel of latitude, while those of the south are not unfrequently found northward as far as the Cape of Good Hope, or, on an average, at 10 degrees lower latitude.

240. As climatological agents, snow and ice have considerable influence on the regions in which they occur. Accumulating on mountain-heights, they are the perennial sources of the springs and streams that descend to refresh and fertilise the thirsty lowlands; while in tropical countries the winds that pass over them are cooled, and flow downwards to temper the sultry atmosphere of the plains below. Masses of floating ice are productive of similar results, the seas and coasts in their vicinity being cooled by their presence, and fogs and rain-storms generated as they melt away. In the higher latitudes, on the other hand, where the winters are severe, snow forms a warm covering for the soil (the *snow-blanket*, as it is termed by farmers), and greatly defends vegetation from the rigour of the frost. Within the polar circle, also, the darkness of the long winter is considerably diminished by the *snow-sheen* or *snow-blink*—snow reflecting, instead of absorbing like the bare ground, the faint light that there proceeds from the sky. The grinding, grooving, and smoothing effects of glaciers on rock-surfaces, and the rock-transporting powers of icebergs, are facts now well known to Geology; and though their consideration belongs more immediately to that science, the results now and in time past cannot be altogether overlooked by the student of Physical Geography.

Causes affecting Climate.

241. In its technical sense, the term *climate* (Gr. *klima*, an inclination) denotes an imaginary belt of the globe parallel to the equator, and so called by the earlier geographers, because the differences of these climes depend on the inclination or obliquity of the sphere. Between the equator and the polar circle there were twenty-four such climatic belts—each depending on the increasing length of the day (half an hour's increase for each belt), and of course expanding in breadth from the equator towards the poles. From the polar circles to the poles there were six climes—the differences of the longest day in their case being counted by monthly periods instead of half-hours. The term is now employed in a much wider sense, as embracing the entire *weather-conditions* of any district, and as such we shall now proceed to

consider its relations. Although the climate of a locality is mainly dependent on its heat and moisture, yet so many circumstances tend to disturb and modify these conditions, that the subject becomes extremely complicated and difficult of determination. Latitude, height above the sea, distance from the ocean, nature of soil, distribution of land and water, direction of mountain-chains, winds and rains, currents of the ocean, cultivation, and the like, all exert their influence in modifying the weather-conditions or climate of any special locality. Our limits, however, will only permit a brief allusion to the more influential of these modifying causes.

242. As repeatedly stated, the main element in climate is the amount of heat received by the sun, and this diminishes (par. 204) according to the latitude or distance from the equator. Owing, however, to the obliquity of the earth's orbit, the regularity of this decrease is alternately interrupted in either hemisphere, and the respective length of day and night at opposite seasons becomes an important element in climatic diversity. Within the tropics day and night are all but equal—the longest day being little more than thirteen hours, and the shortest nearly eleven. In the latitude of Greenwich the longest day is nearly seventeen hours, and the shortest only seven; while, within the polar circles, there is a brief summer period when the sun never sets, and a corresponding winter season when he never rises. Bearing these facts in mind, it will be readily understood why the year, within the tropics, is divided into two seasons—a wet and a dry. The latter is regarded as the summer, and the former as the winter, but they are in direct opposition to the astronomical seasons, as the rains (par. 233) follow the sun. In some intertropical countries, as the West Indies, there are two rainy seasons and two dry seasons within the year. In the temperate zone, again, the year is divided into four seasons—spring, summer, autumn, and winter; but this regular succession of climatic change can hardly be considered as extending farther than from the 35th to the 60th parallels. In the frigid zones, on the other hand, only two seasons are known—a long and severe winter, during a portion of which the sun never rises above the horizon, and a brief but fervid summer, when that luminary never sets. From these circumstances it will be at once perceived that the torrid zone is the region of greatest heat throughout the year, with comparatively little difference between its seasons; that the temperate zones stand next in order as regards the annual amount received, but experience great difference of temperature during the successive seasons; and that the frigid zones are regions of small annual heat, and at the same time subjected to seasonal extremes.

Such is the general climatic order as regards latitude; though, owing to the smaller extent of land, the decrease of heat as we depart from the equator is more rapid in the southern than in the northern hemisphere—so that, on a general average, the latter is about 3½° warmer than the former.

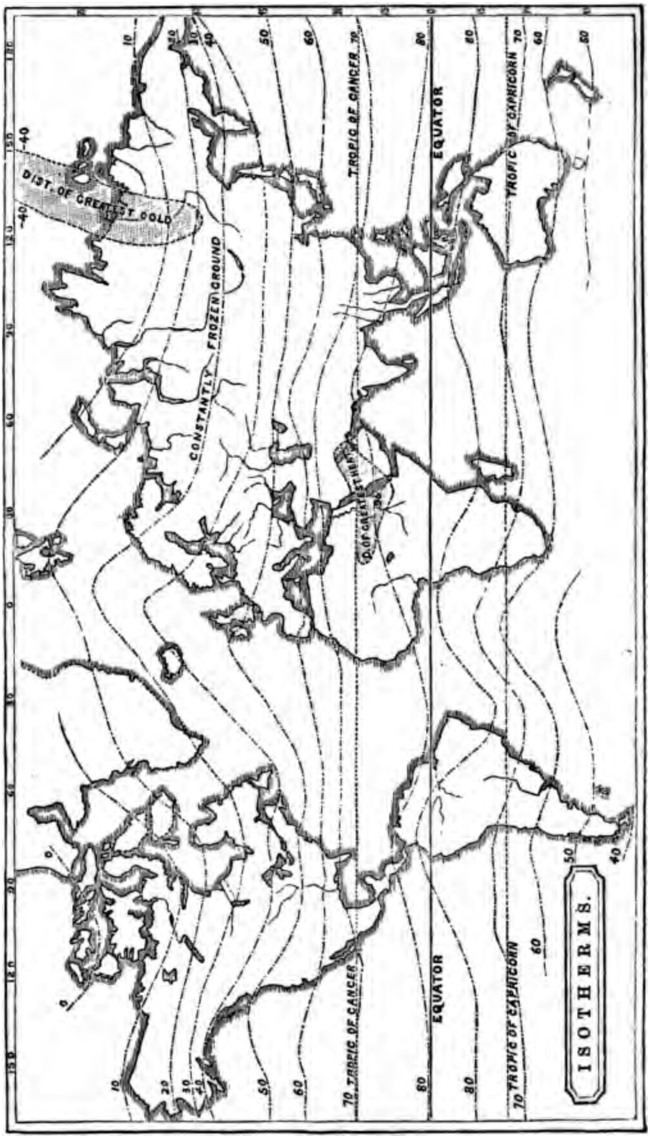
243. Altitude is the next great modifier of climate, but owing to many correlative circumstances (prevalent winds, slope, proximity to the sea, &c.), its operation is not altogether uniform. As formerly stated, a decrease of 1° Fahr. takes place in the lower regions of the atmosphere for every 300 or 350 feet of ascent; but at great heights and in extreme latitudes the decrease is more rapid. As it is, under every latitude the loftier mountains (Himalayas, Alps, Andes, &c.) are perpetually covered with snow; the higher plateaux (Mexico, Bolivia, Armenia, Tibet, &c.) are several degrees colder than the contiguous lowlands; and in temperate zones such table-lands experience much greater extremes of summer's heat and winter's cold than the surrounding districts—having, like Spain, Armenia, and Persia, summers of tropical heat and winters of almost polar severity. Another great cause of modification is the unequal reception and radiation of heat by land and water (par. 206), by which islands and sea-coasts are rendered cooler in summer and warmer in winter than inland tracts—creating what has been termed *insular* and *continental climates*. Britain, New Zealand, and Tasmania enjoy, in this respect, insular climates; Germany, central Russia, and Tartary, continental ones. Connected with this, and depending on the set of the trade-winds and ocean-currents, may be noticed the observation of Humboldt, that the continents and larger islands in the northern hemisphere are warmer on their western than on their eastern sides; while in the southern hemisphere the reverse holds good—the western being the colder and the eastern the warmer.

244. It would exceed the limits of a text-book to describe in detail the many causes concerned in the modification of climates; but besides those of latitude, altitude, and proximity to the sea, may be noticed the following:—1. The direction of mountain-chains, which, by intercepting cold winds, renders the countries on one side warmer than those on the other; and in like manner, by intercepting moist winds, favours the production of rain on the windward slopes and droughts on the leeward or sheltered declivities. The eastern slopes of the Andes, for example, intercept the humid trade-winds from the Atlantic; their counter-slopes on the Pacific side are arid and rainless. 2. The general inclination or slope of a district, as this may lie to the heat of the morning and noonday sun, or be turned to the feebler rays of his afternoon and

evening declension. 3. Owing to their different capacities for heat, the relative masses and configuration of the land and water greatly affect the climatic peculiarities of a country; and this as moist and warm winds generally come from the sea, while cold and dry ones blow from the land—as the seaboard has a moist and cloudy sky that prevents radiation, while the interior has a serene sky that favours it and lowers the temperature—and as this radiation is greater in summer than in winter, and consequently interferes with the amount of heat directly received from the sun. 4. The prevailing winds of a region, as these may be cold or warm, dry or humid. The westerly winds of our own island are humid and warm—the easterly are cold and dry; hence the greater rainfall and mildness of our western coasts as compared with the eastern. 5. As with winds, so in like manner with the influence of oceanic currents. The Gulf Stream, by bringing warmth and moisture, mitigates the winter climate of western Europe; the Arctic current, on the other hand, tempers the summer climate of the eastern shores of North America. 6. The direction of river-plains and valleys, as they open out to favourable winds and ocean-currents. The westerly reception of the Rhine basin produces a finer climate than the easterly trend of the Danube, even though the latter be several degrees farther south; and the southerly slope of the valley of the Rhone enjoys amenities unknown in the westwardly-trending basins of the Loire and Garonne. 7. Cultivation has also a marked effect on the climate of a country—the felling of forests, draining of lakes and morasses, and the like, being all favourable to greater dryness, warmth, and general amenity.

Lines of Equal Heat, &c.

245. Under circumstances mentioned in the preceding paragraphs, it will readily be perceived that the belts of climate can by no means correspond with the parallels of latitude, but that it requires a long series of observations to determine the *seasonal temperatures* of summer and winter, and also a careful average of these to ascertain the *mean yearly temperature* of any given locality. If the surface of the globe had been all water, or all land of equal altitude, the parallels of latitude would have determined the lines of climate; but this not being the case, the daily temperature, the summer and winter temperatures, as well as the mean annual temperature of any two places in the same latitude, may differ very considerably. In this way the maximum


ISOTHERMS.
DIST. OF GREATEST COLD
CONSTANTLY FROZEN GROUND
D. OF GREATEST HEAT
TROPIC OF CANCER
EQUATOR
TROPIC OF CAPRICORN
70 TROPIC OF CANCER
EQUATOR
70 TROPIC OF CAPRICORN

summer heat of an island may be several degrees below that of a continental country between the same parallels, while its winter temperature is many degrees higher. In this way, also, the mean annual temperature of some island or sea-coast may be equal to that of some inland district situated several degrees nearer the equator. A series of lines drawn through places having the same summer temperature show these variations at a glance, and are termed *isothĕral lines* (Gr. *isos*, equal, and *theros*, summer), or lines of equal summer heat; those through places having the same winter temperature, *isocheimōnal lines* (Gr. *isos*, and *cheimon*, *cheimonos*, winter); and those connecting places of the same mean annual temperature, *isothermal lines* (Gr. *isos*, and *therme*, heat). The difference between the summer and winter temperatures may amount to 2°, 20°, 40°, or more degrees of Fahrenheit; but the isothermal lines show the mean amount of heat received throughout the year, and, of course, are the more correct indicators of the general climatic conditions of any given locality. In the accompanying Sketch-Map the isotherms are laid down for every ten degrees, and their bendings northward and southward (according to distribution of land and water, altitude, distance from sea, &c.) convey to the eye instructive proofs of the operating causes adverted to in the foregoing paragraphs.

[In amplification of the preceding remarks on Climatology, the following passage from Mrs Somerville may be read by the student with advantage:—"Places having the same mean annual temperature often differ materially in climate. In some the winters are mild and the summers cool, whereas in others the extremes of heat and cold prevail. England is an example of the first; Quebec, St Petersburg, and the arctic regions are instances of the second. The solar heat penetrates more abundantly and deeper into the sea than into the land; in winter it preserves a considerable portion of that which it receives in summer, and from its saltness does not freeze so soon as fresh water; hence the ocean is not liable to the same changes of temperature as the land, and by imparting its heat to the winds it diminishes the severity of the climate on the coasts and in islands, which are never subject to such extremes of temperature as are experienced in the interior of continents. The difference between the influence of sea and land is strikingly exemplified in the high latitudes of the two hemispheres. In consequence of the unbounded extent of the ocean in the south, the air is so mild and moist that a rich vegetation covers the ground, while in the corresponding latitudes in the north the country is barren from the excess of land towards the Polar Ocean, which renders the air dry and cold. A superabundance of land in the equatorial regions, on the contrary, raises the temperature, while the sea tempers it.

"Professor Dove has shown from a comparison of observations that northern and central Asia have what may be termed a true continental climate both in summer and in winter—that is to say, a hot summer and cold winter; that Europe has a true insular or sea climate in both seasons, the summers being cool and the winters mild; and that in North America the climate is inclined to be continental in winter and insular in summer. The extremes of temperature in the year are greater in central Asia than in North America, and greater in North America than in Europe, and that difference increases everywhere with the latitude. In Guiana, within the tropics, the difference between the hottest and coldest months in the year is only 2°.2 Fahr., in the temperate zone it is about 60°, and at Yakutsk, in Siberia, 114°.4. Even in places which have the same latitude, as in northern Asia compared with others in Europe or North America, the difference is very great. At Quebec the summers are as warm as those in Paris, and grapes sometimes ripen in the open air, yet the winters are as severe as those in St Petersburg. In short, lines drawn on a map through places having the same mean summer or winter temperature are neither parallel to one another, nor to the isothermal or geothermal lines, and they differ still more from the parallels of latitude."]

NOTE, RECAPITULATORY AND EXPLANATORY.

In the two preceding chapters attention has been directed to the Climatology of the globe—that is, to those weather-conditions on which its vegetable and animal life are so intimately dependent. The main medium of climate being the Atmosphere, it was necessary to advert to its nature and composition as an integral portion of our planet. As an aërial fluid, it consists of an admixture of 79 parts nitrogen and 21 oxygen, together with a small but variable proportion of carbonic acid gas, traces of ammonia, &c., and always holding in suspension less or more of aqueous vapour in a visible or invisible form. Constituted as plants and animals are, this composition is indispensable to their existence—the former assimilating carbonic acid and exhaling oxygen, the latter, in counterbalance, exhaling carbonic acid gas and consuming oxygen. Light and invisible as this aërial envelope may appear, it exerts a pressure on the earth's surface, at the sea-level, of about 14¾ lb. avoirdupois to the square inch—a pressure which is balanced by a column of mercury 30 inches in height; hence the *barometric column* of the meteorologist, and the *rise and fall of the barometer* according to changes in the weight of the atmosphere. As an elastic or compressible medium, its lower strata are denser or heavier than those at great elevations; and as its capacity for heat and moisture decreases with its rarity or attenuation, the higher regions of the air are colder and drier than those at a lower elevation.

As the medium through which the light and heat of the sun are conveyed to the terraqueous surface, the atmosphere—partly owing to the varying inclination of the sun's rays, and partly to the unequal reception and radiation of heat by land and water—becomes variously heated in its different regions, and hence arise winds or aërial currents,—the warm air of one locality expanding and ascending, and the colder rushing in from all sides to supply the deficiency. The winds thus generated assume various directions and physical characteristics—the chief cause of modification being the different amounts of heat received by the different zones of the earth. Thus some are said to be *constant,* as the trade-winds of the tropics; others *periodical,* as the monsoons and the sea and land breezes; and others, again, *variable* and irregular, as the winds of the higher latitudes. In their physical characters they are governed chiefly by locality and the nature of the region from which they blow, and are thus hot or cold, moist or dry, relaxing or invigorating—floating as a zephyr that scarcely disturbs the thistle-down, or sweeping as hurricanes that uproot forests and overturn buildings.

The warmer the air, the greater its capacity for moisture; but in every case there is a point beyond which it is incapable of sustaining more vapour in an invisible form. It is then said to be *saturated;* and in this state any cooling, by coming in contact with the colder earth, or by the contact and commingling of colder aërial currents, produces condensation into dews, fogs, rains, snow, hail, and other kindred phenomena. These aqueous phenomena, —whether descending as *dew,* from the unequal temperatures of the earth and air—as *fogs* and *mists,* from unequal temperatures of aërial strata—or as *rains,* by more sudden condensation,—are all essential to the vegetable and animal economies. Rains, like the winds on which they mainly depend, are almost constant within certain equatorial districts; periodical within the regions of the monsoons; and irregular in all the higher latitudes. Some tracts—as the Sahara, Egypt, Arabia, Persia, Mongolia, and Peru —are rainless, or all but rainless; but in most countries the rainfall, though varying from month to month and year to year, is, in the long average, pretty regular and persistent. It will vary, of course, according to latitude, direction of prevailing winds, proximity to the ocean, direction of mountain-chains, and the like; hence its great difference, even on opposite sides of the same island,—annual falls within temperate zones varying from 10 to 80 inches, and within tropical, from 100 to 500 or 600 inches. When the temperature of the air falls below the freezing-point, fogs and mists are converted into snow, and rain into hail—*snow* being mainly an extra-tropical and winter precipitation, *hail* occurring in all latitudes and at all seasons of the year. Within the tropics at the level of the sea snow is unknown; in temperate zones it falls less or more during winter; but in polar regions, and at great elevations above the sea in all latitudes, its presence is perennial. The altitude at which snow remains unaffected by the heat of summer (the *snow-line*) varies with the latitude—descending from 14,000 or 16,000 feet at the equator to near the sea-level at either pole. The latitudinal limit, north and south (the *snow-limit*), varies also according to the distribution of sea and land—receding and advancing as either element prevails. The perpetual presence of snow and ice on lofty mountain-ridges and polar uplands gives rise to *avalanches*, *glaciers*, and *icebergs*—phenomena whose geological influences are not less apparent than their climatological.

The causes which affect the *climate* or weather-conditions of any locality are thus extremely varied—latitude, altitude, distribution of land and water, proximity to the sea, prevalent winds, direction of mountain-chains, slope, nature of soil, cultivation, and the like, all more or less exerting their modifying influences. Heat and moisture, however, are the great regulators of climate; and thus, in general terms, climatological zones may be said to decrease in importance from the equator to the poles. Nevertheless, this decrease by no means coincides with the parallels of latitude; hence to determine the mean temperature of any locality, numerous thermometrical observations have to be made at hourly, daily, monthly, and yearly intervals. The results of such observations enable the meteorologist to connect places having the same summer, winter, and mean annual temperatures; and hence the scheme of exhibiting them at a glance by means of *isotheral*, *isocheimonal* or *isocheimal*, *isothermal*, and other lines.

To the student who would enter more fully into the consideration of the atmosphere and its phenomena, and especially into the subject of climatology as affecting the plant-life and animal-life of the globe, we would recommend perusal of some treatise on meteorology, as that by Professor Kaemtz (an English translation of which appeared in 1845); the essay by Sir John Herschel, which has been republished from the 'Encyclopædia Britannica;' Dr Thomson's 'Elements;' or the still briefer and simpler compilation of Professor Brocklesby of Hartford, U.S.,—a work of much greater merit than pretension.

XIII.

LIFE—ITS DISTRIBUTION AND FUNCTION.

Life as affected by External Conditions.

246. Having noticed the general relations of the Land, Water, and Atmosphere, and the principal phenomena arising therefrom, we now turn to the Life by which they are respectively peopled. Hitherto we have dealt with the *inorganic* phases of nature; we have now to consider the *organic*. In the former case, the study involved consideration merely of *chemical and mechanical forces* acting from without; now we have to deal with the superaddition of *vital action* operating through peculiar organs from within. The material aspects and relations of nature form the themes of the physicist; the vital or organic constitute the study of the physiologist. Under the term *Life* is embraced all that appertains to the vegetable and animal kingdoms—subjects which belong to the domain of Botany and Zoology, and only come under the notice of Geography in as far as they are dependent on external conditions for their position or distribution on the globe. The origin, nature, and function of Life form the theme of Biology; its distribution and external relations become important considerations in the study of Physical Geography.

247. Whatever be the nature and origin of Life, it is clearly dependent for its continuance on the physical conditions by which it is surrounded. A little more heat or a little more cold, a little more moisture or a little more drought, and the plant flourishes or decays, the animal increases or dies. It is obvious, then, that, on a globe having different zones of climate, having regions of excessive humidity and regions of excessive drought—and having, moreover, different areas of land and water—life must be as diversified in its nature as the conditions under which it is destined to exist. The arrangement of plants into aquatic, terres-

trial and aërial—into flowering and flowerless—into trees, shrubs, herbs, grasses, mosses, lichens, sea-weeds, &c.—belongs to the province of Botany; and of animals into aquatic, terrestrial, and amphibious—into mammals, birds, reptiles, fishes, shell-fish, &c.—belongs in like manner to the province of Zoology. What the geographer has more especially to consider is their distribution over certain areas, the physical conditions apparently concerned in their restriction to these areas, and the dependence of the one kingdom upon the other, as completing the economy of nature. As it is Life that gives to creation its highest interest, so the consideration of its relations becomes the highest theme of our subject. For the sake of brevity, the term *flora* (Lat.) is employed to designate the plant-life of a region or epoch, and the term *fauna* its animal-life; hence we speak of the "Flora of South America" and the "Fauna of South America," as well as of the Flora and Fauna of the Tertiary, the Chalk, or any other geological period.

248. So far as the eye, or the eye aided by the microscope, can perceive, life is everywhere present—in the air, on the earth, and in the water, or even parasitic on and within other plants and animals. Unless, perhaps, among the perpetual snows and ices of the poles and lofty mountain-peaks, or in the extreme depths of the ocean, its manifestations are sufficiently apparent; and even in these situations some forms unknown to observation may find a permanent or temporary home. And yet, universal as life may appear, it is confined to the merest film of the terraqueous globe. A few thousand feet above the sea-level on land, and a few thousand feet beneath it in the waters, limit this *stratum of life* on either hand. Thickest at the equator, it thins out towards the poles; and densest near the sea-level, it becomes rarer and rarer the more it rises above or falls beneath this line of greatest intensity. Heat, light, moisture, and nature of soil are the great regulators of life on the land; heat, light, depth, nature of bottom, and saline composition, the main regulators in the ocean. Were it not for these causes there is no reason why the same forms of life should not prevail in every region from the equator to the poles, and from the shore-line to the darkest abysses of the ocean. The influence, however, of external conditions is insuperable. The palm of the tropics would dwarf and die in the temperate zone; the whale of the Greenland seas would perish in the waters of the equator; the rush that luxuriates in the marsh would wither if transferred to the arid upland; the shell-fish that swarm within the influence of the tides would die if submerged to the depth of a few hundred fathoms; the fresh water that forms the vital ele-

ment for one family becomes the poison of another that has been destined to inhabit the saline waters of the ocean.

249. Every plant and every animal is, therefore, adapted by nature to the position it occupies, and within that position continues to fulfil its function so long as the surrounding conditions remain unchanged. Why one genus or kind should differ from another genus, man may never know; and, at all events, the inquiry belongs to the general subject of biology, and not to that of geography. Again, why certain forms should only appear in certain regions—the kangaroo, for instance, in Australia, the ostrich in Africa, and the llama in South America—while other regions seem equally fitted for their residence, is a question involving considerations of origin, and of geological alternations of land and water, that lie beyond the scope of our subject. What more immediately concerns geography, are the existing distribution of plants and animals, the conditions accompanying that distribution, and the question how far they are capable of being transferred to, and acclimatised in, other districts for the luxury and necessities of man. These are the subjects of importance to the merchant, trader, and farmer—the determination of the regions of supply, the amount and quality of products, and the possibility of the profitable growth and cultivation of the plants or animals in other countries than those which they naturally occupy.

250. Some tribes have naturally a wider range than others; some, again, have a more elastic constitution, and are capable of enduring greater diversities of climate; and others, obeying the instincts of food, procreation, &c., migrate from the unfavourable season of one region to the favourable season of another. Of all animals man has the widest range—his superior intelligence enabling him to modify and overcome conditions that would be fatal to other creatures. Many, however, of the domesticated animals and cultivated plants have also considerable elasticity of constitution, and thus man has been enabled to carry them along with him over the greater part of the habitable globe. In this way we require to distinguish between the truly *indigenous* or native products of a country, and the *exotic* or imported, though many species have been so long transferred and re-transferred that it is now impossible to point to their original habitats. While, therefore, there is a natural apportioning of plants and animals to certain areas, and while external conditions are evidently the main regulators of this distribution, it must ever be borne in mind that man has already modified, and is continually modifying, this distribution by transferring, cultivating, and destroying, according as his wants and wishes may compel. His

operations, however, can never extend beyond a mere modification; for over and above his control remain the great conditions of heat, light, moisture, &c., which ever govern the main geographical arrangements of plants and animals; and it is to these in particular that the limits of a text-book will permit us to refer.

Plant-Life—its Distribution and Governing Conditions.

251. As already mentioned, heat, light, and moisture are the principal conditions affecting the terrestrial distribution of vegetable life. These conditions have their greatest intensity near the equator; hence the greatest exuberance of vegetation within the tropics, and its gradual declension as we proceed towards either pole. As might be anticipated, however, this declension is governed more by the isotherms than by the parallels of latitude—the mean amount of annual heat being the predominant condition in vegetable distribution, though the amount of summer heat (isotheral) has also much to do with its ripening and perfection. The mean annual temperature of two places may be the same, and yet the summer temperature of the one may be 10° higher than that of the other, while the winter temperature may be 15° or even 20° lower. Much, therefore, in Botanical Geography depends upon the amount of heat which a plant receives during the period of its greatest activity, and this, in general, is regulated more by the monthly than by the annual isotherms. The zones of vegetation shading more gradually into each other than the astronomical zones (torrid, temperate, and frigid), botanists make a minuter subdivision of the earth's surface into equatorial, tropical, sub-tropical, warmer-temperate, colder-temperate, sub-arctic, arctic, and polar—each characterised by some peculiar feature, though partaking on either side of the forms that belong to the two adjacent zones.

252. The *equatorial* zone, bounded by the isotherm of 79°, is characterised, wherever moisture is present, by its luxuriant vegetation. It embraces the central regions of Africa from shore to shore, Ceylon, the southern portion of the Indian peninsula, Malaya, the Indian Archipelago, the northernmost parts of Australia, New Guinea, and other Pacific islands in the same latitudes, a large portion of equatorial South America, including Columbia, Peru, Guiana, and the northern parts of Brazil. Succulent stems, large and showy flowers, gigantic parasites and climbers, arborescent grasses (canes, bamboos, &c.), orchids, palms, bananas, bread-fruits, custard-apples, silk-cottons, banians, Adansonias, and the

like, are typical of this belt, the greater portion of which, for reasons given in the preceding chapter, lies to the north of the equator.

253. The *tropical* zones, extending to the isotherms of 73½° on either side of the equator, include, in the New World, Bolivia, Brazil, and Paraguay in the southern hemisphere, and the West Indies, Yucatan, Guatemala, and part of Mexico in the northern; while in the Old World it embraces Nubia, Senegambia, Madagascar, Mauritius, and North Australia in the southern hemisphere, and South Arabia, India, Burmah, and southern China in the northern. These zones are characterised by palms, bananas, pineapples, tree-ferns, species of fig, pepper-shrubs, cinnamon, indigo, cotton, coffee, sugar-cane, &c.—there being fewer parasites, and more underwood in the forests. And it has been further remarked by the botanist, that as palms and bananas may be said to mark the equatorial zone, so may arborescent ferns and species of fig be said to predominate in the tropical.

254. The *sub-tropical*, bounded by the isotherm of 63°, embrace Southern Africa and Australia, Paraguay, La Plata, and Chili in the southern hemisphere; and North Africa, Egypt, Syria, North Arabia, Persia, Northern India, part of China, the Southern States of North America, Mexico, and California in the northern hemisphere. They are characterised by a luxuriant growth of magnolias, laurels, myrtles, and figs, together with certain palms, zamias, cactuses, and arborescent euphorbias. In these zones, as in the damp regions of the preceding belts, vegetation is green throughout the year, and the climate, unless where rainless, is described as delightful. They are pre-eminently the lands of the laurel and myrtle.

255. The *warmer-temperate*, limited by 53½°, are still regions of evergreens, but are marked by the absence of palms—the dwarf palm of Europe, the palmetto of North America, and the Chilian palm, being, as it were, outlying forms from the sub-tropical zone. Deciduous forest-trees, oaks, chestnuts, &c., and figs, oranges, pomegranates, olives, and the vine, are typical of the warmer-temperate in the northern hemisphere; shrubby ferns, arborescent grasses, and araucariæ in the southern. This "region of evergreen trees," as it has been called, embraces the well-known flora of southern Europe, as well as those of Asia Minor, the north of China, and Japan.

256. The *colder-temperate*, bounded by the mean annual temperature or isotherm of 42½°, is, in the northern hemisphere, the great zone of deciduous forest-trees, or those which shed their leaves in winter—hence the seasonal contrasts unknown in warmer regions. The characteristic vegetation of this zone is well seen in

that of our own country, the north of France, and Germany—forests of coniferous trees (fir, pine, yew, &c.) and expanses of heath adding peculiar features to the area. The cultivation of wheat scarcely extends beyond this zone in the northern hemisphere; in the southern it is occupied chiefly by the ocean—Tierra del Fuego, Falkland Islands, and Kerguelen's Land being the only important portions.

257. The *sub-arctic* zone, limited by the isotherm of 39°, is characterised by coniferous trees (pine, larch, spruce, juniper, &c.), poplar, beech, grasses, and heaths; and, on its northern limits, by birch, willow, and alder, which become dwarfed, and never attain to the size of trees. "This zone," says Professor Balfour, "is of less extent than the preceding, and in the interior of Asia it is perhaps not so easily distinguishable from it as in Europe. In the northern hemisphere it is the zone of firs and willows; in the southern it embraces a few barren islands. The northern parts of Siberia and Norway, the Faröe Islands, and Iceland belong to this zone. In the Faröe Islands barley does not always ripen, but the turnip and potato generally succeed. The Amentiferæ (plants bearing catkins) in these as well as in Iceland do not become trees. Grasses, common heath, and juniper, form features in the physiognomy of Iceland; in Siberia, forests of pine, larch, spruce, poplar, and birch occur."

258. The *arctic* zone (which has no equivalent in the southern hemisphere, where the ocean alone prevails) is marked by the dwarf birch, alder, and willow; by occasional pines and firs; by grasses; and by numerous lichens and mosses on its northern limits. At Hammerfest, in lat. 71°, according to the authority just quoted, potatoes, turnips, cabbage, and carrots generally succeed. In the American section, rhododendron, andromeda, and azalea are not unfrequent.

259. The *polar* zone is characterised chiefly by its flowerless plants—lichens and mosses—though, during its brief summer, species of ranunculus, saxifrage, scurvy-grass, rush, willow, &c., make their appearance. In this zone there are no trees nor bushes, nor any cultivation of plants for food. In the cold zones it has been remarked that there are more genera and fewer species, and that while the species are few, the individuals are numerous.

260. Such, in general terms, is the characteristic distribution of vegetable life as we proceed from warmer to colder latitudes. But the student is already familiar with the fact that temperature decreases not only as we proceed from the equator towards the poles, but also as we ascend from the level of the sea into the higher regions of the atmosphere. This ascent—*hypsometrical*, as it is

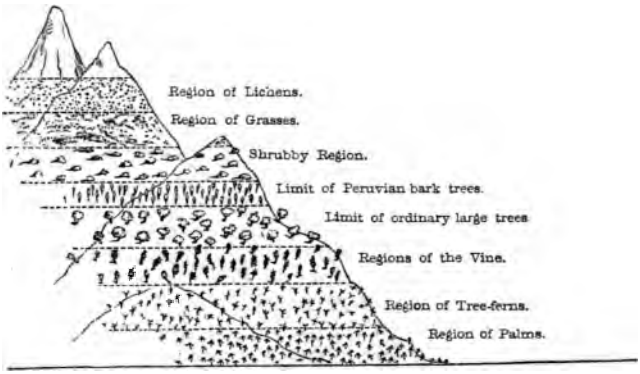
technically termed (Gr. *hypsos*, height, and *metron*, measure)—is marked by analogous belts of vegetation; and at the equator, for instance, the traveller who ascends a lofty mountain passes through a flora much akin to that which marks the successive horizontal zones alluded to in the preceding paragraphs. "We pass," says Herschel, "through the same series of climates, so far as temperature is concerned, which we should do by travelling from the same station to the polar regions of the globe; and in a country where very great differences of level exist, we find every variety of climate arranged in zones according to the altitude (hypsometrical zones), and characterised by the vegetable productions appropriated to their habitual temperature." Thus Humboldt, in describing the South American Alpine flora, remarks:—"In the burning plains scarce raised above the level of the Southern Ocean, we find bananas, cycads, and palms in the greatest luxuriance; after them, shaded by the lofty sides of the valleys in the Andes, tree-ferns; and next in succession, bedewed by cool, misty clouds, cinchonas (Peruvian-bark trees) appear. When lofty trees cease, we come to aralias (ivies) and myrtle-leaved andromedas (heaths); these are succeeded by bejarias abounding in resin, and forming a purple belt around the mountains. In the stony region of the Paramos, the more lofty plants and showy flowering herbs disappear, and are succeeded by large meadows covered with grasses, on which the llama feeds. We now reach the bare trachytic rocks, on which the lowest tribes of plants flourish. Paramelias, lecidias, and leprarias (lichens), with their many-coloured thalli and fructification, form the flora of this inhospitable zone. Patches of recently-fallen snow now begin to cover the last efforts of vegetable life, and then the line of eternal snow begins."

261. In the Old World similar phenomena present themselves; and out of numerous examples we may take the following account of the Himalayan vegetation, as observed by Madden and Strachey in their journey from the plains of India, through Kemaon, to Tibet:—"Ascending, we find forms of temperate climates gradually introduced above 3000 feet, as seen in species of pine, rose, bramble, oak, berberry, primrose, &c. At 5000 feet the arboreous vegetation of the plains is altogether superseded by such trees as oak, rhododendron, andromeda, cypress, and pine. The first ridge crossed ascends to a height of 8700 feet in a distance of not more than ten or twelve miles from the termination of the plains. The European character of the vegetation is here thoroughly established; and although specific identities are comparatively rare, the representative forms are most abundant. From 7000 to 11,000 feet—the region of the Alpine forest—the trees most common are oak,

horse-chestnut, elm, maple, pine, yew, hazel (growing to a large tree), and many others. At about 11,500 feet the forest ends—Webb's pine and the Bhojatran birch being usually the last trees. Shrubs continue in abundance for about 1000 feet more; and about 12,000 feet the vegetation becomes almost entirely herbaceous. On the southern face of the mountains the snow-line is probably at an elevation of 15,500 feet. The highest dicotyledonous plant noticed was at about 17,500 feet, probably a species of echinospermum. A nettle, also, is common at these heights. The snow-line here recedes to 18,500 or 19,000 feet. In Tibet itself the vegetation is scanty in the extreme, consisting chiefly of caragana, species of artemisia, potentilla, and a few grasses. The cultivation of barley extends to 14,000 feet. Turnips and radishes, on rare occasions, are cultivated at nearly 16,000 feet. Vegetation ends at 17,500 feet: scanty pasturage being found only in favoured localities at this elevation; and the highest flowering plants are corydalis, cruciferæ, sedum, and a few others."

262. In temperate latitudes, though the variety of vegetation be less, and the lower zones of tropical flora be necessarily wanting, similar phenomena present themselves. "We may begin the ascent of the Alps, for instance, in the midst of warm vineyards, and pass through a succession of oaks, sweet chestnuts, and beeches, till we gain the elevation of the more hardy pines and stunted birches, and tread on pastures fringed by borders of perpetual snow. At the height of 1950 feet the vine disappears; and at 1000 feet higher the sweet chestnuts cease to thrive; 1000 feet farther, and the oak is unable to maintain itself; the birch ceases to grow at an elevation of 4680 feet; and the spruce fir at the height of 5900 feet, beyond which no tree appears. The rhododendron then covers immense tracts to the height of 7800 feet; and the herbaceous willow creeps 200 or 300 feet higher, accompanied by a few saxifrages, gentians, and grasses; while lichens and mosses struggle up to the imperishable barrier of eternal snow." On the Pyrenees, in like manner, the following belts have been observed:—1. The zone of vine and maize cultivation, and of the chestnut woods. 2. A zone extending from the limit of the vine to about 4200 feet, at which limit the cultivation of rye ceases; here we meet with box, saxifrage, gum, &c. 3. From the limit of the cultivation of esculent vegetables at 4200 feet to the zone of the spruce-fir. 4. From the limit of the spruce fir zone, at 6000 to 7200 feet, characterised by the presence of the Scotch fir. 5. From 7200 to 8400 feet is an Alpine zone, characterised by the dwarf juniper, Saxifraga bryoides, Soldanella alpina, Juncus trifidus, &c. 6. A zone above 8400 feet exhibits a few Alpine

species, as Ranunculus glacialis, Draba nivalis, Stellaria cerastoides, Androsace alpina, and Saxifraga Gröenlandica. The accompanying sketch exhibits, in general terms, the order of these ascending zones of vegetation, from the sea-level at the equator to the limit of perpetual snow.



Hypsometrical Zones of Vegetation.

263. Besides the great governing conditions of temperature, as dependent on latitude and altitude, there are others arising from light, slope, nature of soil, moisture, &c., which, though less general, are nevertheless equally imperative. The southern slopes of a mountain-range, exposed to the full influence of the sun's rays, exhibit not only a greater profusion of foliage and blossom, but a greater variety of species than is to be found on the northern and darker side. Even the southern side of a tree will make a larger amount of annual growth, and present a greater exuberance of flower and fruit than the northern. And yet, though heat and light are so indispensable in the economy of vegetable life, influencing their luxuriance, colours, and secretions, it must be remembered that while some families require full exposure to these influences, others luxuriate only in the shade. Nor must it be forgotten, as already noticed under Climatology, that the *quality* of the sun's rays is affected alike by altitude and the nature of the atmosphere (clear, or dense and foggy) through which they pass; and hence the difference of their influence on plants and animals. "The chemical rays of the spectrum," says Sir J. Herschel, "are powerfully absorbed in passing through the atmosphere, and the effect of their greater abundance aloft is shown in the superior brilliancy of colour in the flowers of Alpine regions." As to the

effects of density, or pressure at great heights, it is questionable whether it is at all appreciable—the diminished temperature at such altitudes being the main cause of change in the plant-life of such situations.

264. Again, the influence of soil is equally observable: hence we seek in vain on the clayey moorland for the species that form the rich and verdant carpeting of the calcareous district; or on the thirsty sand-dunes by the sea-shore for the flora that flourishes so freely on the alluvial meadow. This influence arises, of course, partly from the mere mechanical nature of the soil, and its capabilities of retaining heat and moisture, and partly also from chemical composition—the plant deriving therefrom certain ingredients which are necessary to the healthful growth and elaboration of its tissues and secretions. Every geologist has noted the difference of vegetation on the different rock-formations of a country, each belt of limestone or clay, of granite or trap-rock, being characterised by a predominance and luxuriance of certain species. Further, some plants are truly littoral, and flourish only (like the mangrove and cocoa-palm) within the influence of the sea-spray; while others become stunted and diseased if exposed, even for a season, to the breath of the sea-breeze.

265. The effect of moisture on the distribution of vegetation is direct and perceptible, arid tracts being comparatively barren, while humid regions, and especially humid and warm ones, are noted for their luxuriance. Even in tropical countries, like South America, the dry season is one of torpidity, and corresponds to the winter of temperate zones—vegetation being dormant till the rainy season returns and once more renews its growth and foliage. It is owing to this influence of moisture that botanists distinguish between rainy and rainless regions, and between zones of summer rains, winter rains, and rains at all seasons—each zone being stamped by its own vegetable aspects. But beyond this common influence of moisture on all vegetable forms, there is a natural adaptation of certain forms to moist situations; and for this reason we have plants—some inhabiting the sea, others lakes and rivers, and some, again, the marsh and mudflat.

266. As plants have a fixed and natural distribution on land, so also they have a similar distribution, horizontal and vertical, in the waters; though, in consequence of the greater uniformity of temperature, the marine areas are less marked and decided. *Horizontally,* the ocean has been divided into certain botanical provinces, of which our limits will merely permit the enumeration: 1. The Northern Ocean, from the pole to the 60th parallel;

2. The North Atlantic, between the 60th and 40th parallels—the great headquarters of *Fucus* proper; 3. The Mediterranean—a sub-region of the warmer-temperate zone of the Atlantic, lying between the 40th and 23d parallels; 4. The tropical Atlantic, in which *Sargassum* abounds (Sargasso Sea, par. 139); 5. The Antarctic American regions, from Chili to Cape Horn, and the whole circumpolar ocean south of 50° of S. latitude; 6. The Australian and New Zealand; 7. The Indian Ocean and Red Sea; 8. The Japan and China Seas, besides certain less decided provinces in the Pacific.

267. *Vertically*, or *bathymetrically*, as it is termed when treating of the ocean (Gr. *bathys*, deep; *metron*, a measure), light, depth, and nature of sea-bed seem to be the prime regulators of aquatic vegetation. In the limited areas of streams and fresh-water lakes the order of arrangement is less perceptible, but in the ocean each gradually-deepening zone is characterised by its own peculiar forms. Thus, in the British seas naturalists speak of a littoral, laminarian, coralline, and coral zone; and in the ocean generally, of a littoral, circum-littoral, median, infra-median, and abyssal or deep-sea zone. The nature of these bathymetrical subdivisions will be best understood by referring to our own shores, where the *littoral* is that which lies between high and low water mark, and is characterised by such plants as the bladder-wrack, dulse, and carigeen; the *laminarian*, that which commences at low-water mark, and extends to a depth of from 40 to 60 feet, and marked, as its name implies, by the broad waving tangle (*laminaria*), and larger algæ; the *coralline*, that which extends from 90 to about 300 feet in depth, and where corallines luxuriate, and the common sea-weeds disappear; and the *coral zone*, which lies between 300 and 600 feet, and is the region of the calcareous and stronger corals. In the abysses of the ocean diatoms (microscopic vegetable forms) alone occur; and generally as the corallines increase the true sea-weeds disappear, ordinary algæ scarcely existing beyond a depth of 300 feet.

268. Admitting, however, in the fullest degree, the influence of heat, light, moisture, and the like, in the distribution of vegetable life, there still lies over and above them a primal arrangement, by which certain forms are naturally restricted to certain areas. This arrangement, which is seemingly not dependent on climate (for the plants thrive equally well when transferred to other areas), imparts a certain physiognomy to these regions; and thus botanists, entering more minutely into the geographical aspects of their science, subdivide the earth into *regions* and *provinces* according to their prevalent floras. Such subdivisions lie beyond

the limits of our outline, but the learner will readily perceive their bearings when he considers—*first*, that some forms, like the tea-plant and camellia, are peculiar to eastern Asia; some, like the eucalypti and casuarinæ, to Australia; others, like the magnolia, to the southern latitudes of North America, and so on: while, *second*, that every tribe of plants has a special aspect or physiognomy, and where such tribes prevail, that physignomy will be imparted to the landscape. Wherever, therefore, certain orders are peculiar, and a certain number of genera and species prevail, this constitutes a botanical "region," such as the region of saxifrages and mosses, the region of magnolias, the region of camellias and teas, region of palms, and so on, making in all some twenty-four regions, into which the earth's surface has been botanically divided. In like manner with aspect or "physiognomy," as the Palm form, the Banana form, the Mimosa form, Cactus form, Heath form, Grassy form, Willow form, &c.—there being in all twenty-two such forms, which are readily distinguished even by the eye of the unbotanical observer.

269. In the same way it is not unusual to divide the Old and New World into *agricultural* zones, in something like the following order, from the tropics to the northern limit of profitable culture—1. Zone of rice and maize; 2. Maize and wheat; 3. Wheat, rye, buckwheat, pease, and beans; 4. Barley, oats, and potato. Commenting on the agricultural zones, Professor Balfour remarks, that in the Old World, "the *zone of barley, oats, and the potato*, includes Finmark and the higher districts of Scandinavia, the Faröe Islands, and the most northerly part of Scotland and Ireland—the north boundary being 62°, 70° and 67°, and the south boundary 57° in Scotland, 52° in Ireland, 65°, and 60°. That the *zone of rye and wheat* occupies the greater part of Europe north of the Alps, and extends to about 50° latitude, or as far as the polar limit of the cultivation of the vine; and that in this zone buckwheat, pease, and beans, are also important articles of food. That the *zone of wheat* includes those parts of Europe and western Asia which lie south of the 50th degree; and that in several districts maize is cultivated as well as wheat. That the *zone of rice and wheat* embraces those provinces which are subject to the influence of tropical seasons—in tropical western Africa rice and maize being the chief grains. This zone extends from about 15° N. lat. to about 28° S. lat." In the New World, Berghaus distinguishes the following zones:—1. Rye, wheat, and barley (summer cereals); 2. Rye and maize; 3. Wheat and maize; 4. Wheat. In the tropical zone maize is the principal cereal grown.

270. *Economically* or *commercially*, it has also been attempted to arrange the earth's surface into four great vegetable zones—the tropical, southern temperate, northern temperate, and arctic, each, no doubt, shading into the other, but still, on the whole, broadly made up of its own peculiar products. The *first*, for example, is characterised by and yields such produce as dates, bananas, cocoa-nuts, tamarinds, guavas; yams, melons, cassava, sago, maize, rice; sugar, coffee, cinnamon, cloves, nutmegs, pepper, ginger; vegetable butter, vegetable ivory, gutta-percha, caoutchouc; aromatic gums, vanilla, opium, betel; cotton, indigo, dye-woods, sandal-wood, mahogany, teak, &c.: the *second* by the date, orange, lemon, fig, pomegranate, olive, vine; rice, maize, millet, wheat, barley; the potato; tea, Paraguay tea; cotton in the northern part, and flax and tobacco throughout; walnut, chestnut, cork, mimosa, birch, &c.: the *third* by the apple, pear, cherry, plum, gooseberry, currant, strawberry, cranberry; wheat, barley, oats, buckwheat; tobacco, hops, flax, hemp; beet, turnip, cabbage; oak, ash, beech, birch, maple, lime, elm, alder, pine, larch, &c.: and the *fourth* by the gooseberry, currant, strawberry, cranberry; Iceland and reindeer moss; Scotch fir, larch, birch, alder, willow, and juniper.

271. Such, in general terms, is the distribution of plants over the surface of the globe. Though many families have a very narrow range, and naturally are never found beyond it, yet others having greater facilities for the dispersion of their seeds, and being, moreover, of a more elastic constitution, have a tendency to increase their area, and this often at the expense of other families that are destroyed by their presence—nature exercising, as it were, a power of selection, by which some races are extinguished and others brought prominently forward to predominate for a period, and then to give way in turn to new and advancing species. Others, again, possessing this greater adaptability, are transferred for their utility or ornament from region to region, and are now found *acclimatised* and growing luxuriantly in many countries to which they naturally would never have found their way. In general, however, the great natural laws of distribution are supreme, and the majority of plants attain their perfection only in the habitats to which they originally belong. In densely-peopled and cultivated countries man is ever destroying, transferring, and acclimatising; but, knowing the limit to which this power can be profitably exercised, he will cease to rear in one region what can be more abundantly and cheaply procured from another. It is thus that a knowledge of the geographical distribution of plants, and the laws on which that distribution depends,

becomes a subject not only of scientific interest, but of true economic importance.

272. The great question—How the globe has been clothed with its present vegetation? is one that belongs more to the domain of botany than that of geography; and yet on this point we cannot refrain from transcribing the very cautious and temperate views of the authority above quoted. "From all that has been said on this interesting subject," he remarks, "we are led to the conclusion that many plants must have originated primitively over the whole extent of their natural distribution; that certain species have been confined to definite localities, and have not spread to any great distance from a common centre; while others have been generally diffused, and appear to have been created at the same time in different and often far-distant localities; that migration has taken place to a certain extent, under the agency of various natural causes; that geological changes may, in some instances, have caused interruptions in the continuity of floras, and may have left isolated outposts in various parts of the globe; and, finally, that social plants were probably created in masses, that being the natural arrangement suited to their habits."

XIV.

LIFE—ITS DISTRIBUTION AND FUNCTION.

Animal Life—its Distribution and Governing Conditions.

273. BEING influenced by climate, food, and other external conditions, animals, like plants, are necessarily less or more restricted to certain geographical regions. Endowed with greater powers of dispersion and locomotion, their limits are, perhaps, less precise than those of plants; but in the main there is a similar horizontal and vertical arrangement of animal forms—from the equator to the poles, and from the sea-level to the loftiest heights of land, or to the greatest depths of ocean. The *fauna* of the tropics, taken in general terms, is more exuberant in kind, in size, strength, and beauty, than that of the temperate zones; and this, again, more abundant than that of the arctic and antarctic regions. The more luxuriant and sheltered lowlands are peopled by races differing from those that inhabit the mountain-slopes, and those that affect the mountain-sides are distinct from those that find subsistence among the higher and colder elevations. In like manner, the creatures that throng the shallow shore are specifically different from those that are scattered through the deeper ocean. In the great *stratum of life* every plant and animal has its own natural horizon, and in that horizon it takes some particular spot better fitted for its growth and development than another—and this spot in the case of a plant is known as its *station*, and in the case of an animal as its *habitat.*

274. In this way terrestrial animals may be broadly arranged into a tropical, a temperate, and an arctic fauna—each shading to a certain extent into the other, but still, in the main, characterised by genera and species that do not naturally occur in the other sections. Thus, the Tropics are the great headquarters of the apes and monkeys; of the lion, tiger, panther, hyena, and larger carnivora; of the giraffe and zebra; the elephant, rhinoceros,

hippopotamus, and tapir; the crocodile, turtle, boa, and larger reptiles; the ostrich, flamingo, peacock, parrots, humming-birds, and generally of birds remarkable for their brilliant and variegated plumage. Insect life is also much more varied and exuberant in tropical than in colder latitudes—attaining its maximum in variety, in size, activity, and brilliancy of hue, within the luxuriant regions of Brazil, Guinea, and the Indian Archipelago, and gradually declining towards either temperate zone. This declension does not take place, of course, everywhere in the same ratio, for wherever there is abundance of plant-life, there certain insects increase in corresponding numbers; and variety in plant-life is also attended by a greater variety of insect-life—each genus, and often each species, being limited to its own peculiar vegetation.

275. The Temperate zones, on the other hand, though marked on their warmer limits by the presence of such tropical forms as the tiger, jackal, hyena, crocodile, &c., are, on the whole, the headquarters of such ruminants as the ox, bison, buffalo, goat, sheep, stag, and elk. The useful animals—that is, those more especially fitted for domestication, like the horse, ox, sheep, dog, &c.—increase in the milder zones, while the larger carnivora decrease not only in species, but in power and numbers. Peculiar to them also are the Bactrian camel, the wild boar, wolf, fox, and beaver; the opossum in the northern hemisphere and the kangaroo in the southern; the eagle and falcon, turkey, goose, grouse, and pheasant, among birds; while reptiles become fewer and smaller the nearer we approach the arctic zone. Insects also, with the exception of beetles, decrease in species, size, and brilliancy—the beetles being specifically more abundant in temperate than in tropical climes, though inferior in size and brilliancy of colouring.

276. The Arctic zone (for the Antarctic is almost exclusively occupied by the ocean) is characterised by greater uniformity in its fauna, by few species but by numerous individuals, and generally by the quiet and sombre colouring both of its birds and quadrupeds. The reindeer, musk-ox, brown bear, polar bear, wolf, arctic fox, and sable, are peculiar to this region; the sea-fowl that frequent its summer seas are chiefly migrants from the waters of the colder-temperate zone; and reptile life is unknown. And here it may be observed that as the land in the northern hemisphere lies in great contiguous or all but contiguous masses, while in the southern it consists of far-separated spurs and patches, so there is a greater similarity between the fauna and flora of northern than of southern zones. The Life of the Antarctic zone occurs in dissimilar and far-scattered specks and patches, while in the Arctic, the musk-ox, reindeer, polar bear, Esquimaux

dog, and arctic fox occur in uninterrupted continuity wherever they can find a habitable locality.

277. Still more minutely than these great thermal zones, it has been attempted to arrange the earth's surface into certain zoological *kingdoms* and *provinces*, but, it must be confessed, with much less precision and certainty than in the case of the vegetable world. The following epitome of this arrangement, by the late Edward Forbes, may be sufficient for the student at this stage of his progress:—The *first* kingdom embraces Europe, which is again subdivided into northern, middle, and southern provinces. The limit between the northern and central provinces falls about lat. 60° north, or, more accurately, it corresponds with the curve of 41° of mean annual temperature. The separation between the central and southern provinces is formed by the chains of the Pyrenees and Alps. The peninsulas of Spain, Italy, and Greece, with the islands of the Mediterranean, form the southern province, which in the east is divided by the Ural Mountains from the *second* kingdom, which comprises Asia. At the junction of Europe and Asia, on the coasts of the Black Sea and the Caucasus, the European and Asiatic forms of animals are mixed, and pass into each other. There is here a peculiar zoological district—country of Anterior Asia, or the countries of the Caucasus, Asia Minor, Syria, and the table-lands of Persia—which may be designated the "European-Asiatic Transition province," in which are also found specimens of the zoological characters of Africa. Asia is divided also into three provinces, the northern, middle, and southern. The northern province extends from the Volga in the west to the mountain-range of the Altai, with a mean temperature of 42°; and eastward to the shores of the Pacific, where it is bounded by the isotherm of 32°, which marks the limit of permanently frozen ground. This province embraces the whole of Siberia, Kamtchatka, &c. The central province is limited on the south by the Himalayan Mountains, consequently it comprises all Asia from the Caspian Sea to the Pacific Ocean, including the islands of Japan, &c. Beyond the Himalaya begins the southern province, or the Indian world, comprising both peninsulas, a part of the southern province of China, and the whole of the Archipelago. The south-eastern extremity of the zoological region of Asia is so strictly defined by the Moluccas and Timor, that whilst in these islands there is a great abundance of carnivora and other orders of animals, in New Guinea (separated only by a small arm of the sea) they appear to be almost or wholly wanting. We have now reached the oceanic province, which is characterised by a great deficiency of carnivorous animals; southward from it lies the *third*

zoological kingdom, or Australia, which, besides the continent of Australia and Van Diemen's Land, comprises the islands to the eastward, including New Zealand, and the numerous groups of Polynesia, and these, from the small extent of space to which they are confined, the uniformity of the soil, climate, and produce, and consequently uniformity of the animal world, form only one province. The *fourth* kingdom consists of Africa, the peninsula of Arabia, which in its natural character is so closely connected with it, and the islands of Madagascar, Bourbon, and Mauritius. The *fifth* kingdom consists of North and South America, or the New World, and is divided into four provinces—viz., those of arctic, northern, tropical, and southern America. The arctic is divided from the northern province by a curved line, beginning about Prince of Wales Island on the west and passing eastward through the middle of the Canadian lakes. This line coincides with the isotherm of 46°, and the province is chiefly composed of British and Russian America. The northern province extends south to the Gulf of Mexico, whence it is bounded by a line drawn from the mouth of the river Bravo del Norte to the northern extremity of the Gulf of California, and comprises the United States, Texas, and the greater part of Mexico. The tropical province extends through Central America, the Antilles, and all South America, to the parallel of 40° south, where it is joined by the southern province, which comprises Patagonia and the islands south of Cape Horn.

278. As with the terrestrial fauna, so also in a great measure with the marine, though at first sight there may seem no interruption to interchange and community of habitat. Variety of genera and species characterises the seas of the torrid zone; uniformity of species and immense numbers of individuals mark the fauna of the colder latitudes. The fishes and shell-fish of the tropics are noted for their varied and brilliant tints; those of the arctic regions are of uniform and sombre hues. The right whale never traverses beyond the cold waters of the higher latitudes in either hemisphere; the sperm whale, on the other hand, is unknown beyond the tropical areas of the Pacific. Unknown in the torrid zone, the seal and walrus occur in thousands in the colder-temperate and arctic regions. The headquarters of the sharks lie within the torrid zone; the tunny rejoices in the genial waters of the Mediterranean; while the cod, haddock, pilchard, herring, and salmon—the great majority of the food-fishes, in fine—attain perfection only within the colder waters of the higher latitudes. The constituents of the sea-water are nearly the same throughout, and yet the reef-building corals only elaborate their structures within the tropical and sub-tropical expanses of the ocean.

279. As with the horizontal areas of the water, so in like manner with its various depths or bathymetrical zones. The *littoral zone* (par. 267) of our own seas, for example, is characterised, according as the bottom may be rocky, sandy, or muddy, by such shell-fish as the periwinkle, limpet, mussel, cockle, and razor-shell; the *laminarian* by star-fishes, the common sea-urchin, tubularia, modiola, and pullastra; the *coralline* by the disappearance of the ordinary shore shells, and the abundance of buccinum, fusus, trochus, venus, pecten, and the like; and the *coral zone* by forms of star-fish, cidaris, and brachiopod mollusca that cannot exist in shallower waters. As to the extreme depths of ocean, they are generally presumed to be, like the extreme elevations of the land, altogether barren and lifeless. It is true that some recent deep-sea soundings in the North Atlantic would seem to point to a different conclusion; but these, before final acceptance, require the confirmation of further and independent experiment.

280. It must ever be borne in mind, however, that, obvious as may be the influence of external conditions on the distribution of animal life, there is over and above them an aboriginal dispersion that science in its present position is unable to account for. Why, for instance, should the kangaroo and ornithorhynchus be restricted to Australia, the apteryx to New Zealand, the hippopotamus and giraffe to Africa, the camel to the Old World, and the llama to the New? Or why should the New World, notwithstanding its predominance in vegetation, be inferior in variety and intensity of animal life to the Old? But while these aboriginal differences exist and remain unaccounted for, the student should remember that distant regions, having nearly the same conditions, are peopled by what are termed *representative species*—that is, species not zoologically identical, but merely representing one another in the economy of nature, and fulfilling similar functions. Thus, the camel of the Old World is represented by the llama of the New; the lion and tiger of the Old World by the puma and jaguar of the New; the ostrich of Africa by the rhea of South America and the emu of Australia; and the crocodile of the Nile by the gavial of the Ganges and the alligator of the Amazon. It should also be borne in mind that local conditions of food, shelter, healthful position, freedom from enemies, and the like, are also operating causes in the distribution and dispersion of animal life; and that where these are wanting, whole families will shift ground, or altogether disappear, even when the great conditions of temperature remain unchanged.

281. As in the vegetable world, so also (though to a less extent) in the animal, certain species have a greater elasticity of

constitution, which enables them to subsist under a greater variety of conditions, and naturally, therefore, to enjoy a wider geographical range. Operating upon this principle, and a knowledge of climatology, man has been enabled to transfer from one region to another a considerable number of animals, either for the purposes of his convenience or luxury. All the domestic animals —horse, ass, ox, sheep, goat, pig, dog, cat, barn-fowl, &c.; many birds, prized for their beauty or song; and rats, mice, insects, and other creatures, considered as "pests and vermin," have accompanied him over the habitable globe. His efforts in this respect—extirpating, transferring, and acclimatising—have been incessant; and thus creatures naturally of widely distant habitats have been, and are still being, brought together into one common area. In this way the domestic animals of the Old World have been transferred to the New, where they were unknown at the time of its discovery by Columbus; some of the New World fauna transferred to the Old; and not only the domestic animals, but the birds, fish, and even shell-fish of Europe, transported to Australasia, where, within little more than a century, their genera were totally unrepresented. But as in the vegetable world, so in the animal, there is a limit to this system of transference, and man best studies his own interest and the comfort of the lower animals by fostering them mainly within their own native habitats, and sharing in their larger produce through the more profitable method of commerce and exchange.

Interdependence of Plants and Animals.

282. As plants and animals are alike dependent on external conditions, so both are, to a certain extent, dependent on one another. Both, for example, are dependent on the atmosphere, yet the oxygen which the plant exhales is inhaled by the animal, and the carbonic acid exhaled by the animal is absorbed and assimilated by the plant. The plant, rooted in the soil and casting abroad its leaves and branches in the atmosphere, though seemingly deriving the main elements of its growth from inorganic sources, is nevertheless stimulated into life and exuberance by the presence of organic decay, and many of the lower fungus-growths are found only where such decomposing matter is present. Herbivorous animals, as is well known, subsist directly upon plants, while the carnivorous prey upon the plant-feeders, and are thus also ultimately dependent on the vegetable world for their subsistence. Wherever vegetable life is varied and

luxuriant, there animal life is marked by a corresponding variety; hence the specific exuberance of the tropics compared with that of the colder latitudes. By the extirpation of certain plants, certain mammals, birds, and insects may be removed from a district; while, on the introduction of some new exotic, animals hitherto unknown in that locality usually make their appearance. Certain birds, for example, feed on certain insects, and these insects, again, find their chosen food in certain plants; remove the plants and you destroy the insects, and by the destruction of the insects you compel the birds to remove and find supplies in other habitats, or if these supplies cannot be found the birds are extirpated. The law of circulation and interdependence is complete, and no portion of the circle could be removed without a corresponding change in the characters of the vegetable and animal kingdoms.

283. Again, though most plants have the inherent power of dispersing their own seeds, and are aided in this by winds and water-currents, yet many depend upon birds and mammals for their wider dispersion and increase, just as many depend upon insects for the fertilisation of their flowers. This wider dispersion creates a new source of subsistence for the animals that feed upon them, and thus the increased area of the one supplies a wider range to the other. Further, as some animals are fitted by their organisation for an arboreal existence—some for life on the grassy plain, and others for the shrubby thicket—the destruction of the tree, the planting of the plain, or the clearing of the thicket, would necessarily involve the destruction of these special organisations. Still further, as some creatures are specially fitted to live on fruits, some on leaves, and others on roots, the disappearance of these specific supplies would necessarily be followed by the annihilation of the consumers. It is in this manner that plants and animals become co-dependent portions of one great vital plan, and that geographers, aware of these relations, can more intelligibly depict the aspects of nature by associating every fauna with its own appropriate and distinctive flora.

NOTE, RECAPITULATORY AND EXPLANATORY.

In the two preceding chapters attention has been directed to the vital aspects of the globe—that is, to its vegetable and animal life, and their distribution over the land and through the waters. Leaving the nature and origin of Life to the biologist, it has been shown that plants and animals are dependent for their continuance on the external conditions by which they are surrounded, and that any change in these conditions would materially affect, if not destroy, their existence. For this reason, plants and animals have a definite distribution over the globe; heat, light, and moisture being the great regulators of the one; climate and food the governing conditions of the other. In this way vital variety and exuberance culminate within the tropics and decline as we proceed towards either pole—declining also in an analogous manner as we ascend from the level of the sea into the higher elevations of mountains. Each zone or belt of the earth has thus its own special flora and fauna—that is, is characterised by genera and species not naturally occurring in other regions. As marked variations occur within narrower limits than the torrid, temperate, and frigid zones, botanists subdivide the earth's surface into equatorial, tropical, sub-tropical, warmer-temperate, colder-temperate, sub-arctic, arctic, and polar belts; and these, as might be expected, correspond with lines of temperature rather than with parallels of latitude. As in the land, so also in the waters, each zone of depth, from the shore seaward, has its characteristic forms—littoral, laminarian, coralline, and coral; the extreme abysses of ocean, like the extreme altitudes of land, being apparently barren and lifeless.

Beyond these main horizontal and vertical arrangements of life, there is also an aboriginal dispersion of certain races over certain areas which science cannot account for; hence the subdivision of the earth's surface into botanical and zoological "regions" and "provinces," each subdivision being characterised by its own typical forms. These provinces form the special study of the botanist and zoologist; and the question how far the plants and animals of one region can be profitably transferred to another, becomes one of prime economical importance. Understanding the geographical conditions under which plants and animals naturally occur, and knowing, moreover, the intimate dependence between the vegetable and animal kingdoms, man, in his own migrations over the globe, will be better able to determine what to cultivate and what to extirpate, what to attempt acclimatising and what to continue in their own native habitats. Understanding, moreover, the relations that subsist between fauna and flora, he will, as a geographer, be better enabled to draw that intelligible picture of external aspects which it is the grand province of his science to depict; and from a knowledge of these aspects be further enabled to indicate to the merchant and trader the nature and amount of the products which each separate region can supply.

The student who would enter more fully into the distribution of vegetable and animal life may consult for the former such works as Balfour's 'Class-book of Botany,' Lindley's 'Vegetable Kingdom,' Schouw's 'Earth and Man,' Meyen's 'Botanical Geography,' and the various publications of Humboldt, Hooker, and others who have written on botany; and for the latter the letterpress of Johnston's 'Physical Atlas,' the 'Zoologies' of Cuvier, Milne-Edwards, Carpenter, &c.; and the various writings of Agassiz, Darwin, Edward Forbes, and the like, who have ventured on the higher questions of zoological geography.

XV.

ETHNOLOGY—RACES AND VARIETIES OF MAN.

Man as affected by External Conditions.

284. MAN, in whatever stage of civilisation he may appear, is always less or more influenced by the geographical conditions of the region he occupies. Unlike the lower animals, which either simply flourish under or succumb to these conditions, Man may struggle against and so far modify them; but still, to a great extent, his thoughts and actions, his industrial pursuits, his social polity, and religious beliefs, are all affected by the physical circumstances of his position. To argue otherwise were to ignore the principles of science, and lose sight of those zoological relations that subsist not only between man and the other animals, but between him and those external conditions upon which the continuation of his existence is so absolutely dependent. In savage life this influence is direct and perceptible; hence the difference between the semi-aquatic Esquimaux and the hunting Red Indian, though inhabiting the same continent; between the stationary vegetable-feeding islanders of the sunny Pacific, and the wandering omnivorous tribes of the scrubby plains of Australia; between the lithe and nerveless red man of the New World, and the robust and vigorous negro of the Old. Even where civilisation has made some progress, it is these conditions that still mainly determine man's habits and pursuits—rendering the inhabitants of the grassy steppe nomades and herdsmen, the indwellers of the river-plain tillers of the ground and growers of grain, and the men of the sea-coast traders and adventurers. And higher still, where populations have been long settled and civilisation has assumed its most advanced aspects, climate, scenery, natural products, facilities for intercommunication and exchange, are ever exercising their influence—rendering one nation wealthy and independent, another bold and enterprising, and a third, it may be, isolated and

stationary. Nor is it man's mere material condition that is thus affected; his religious sentiments, his poetic feelings, his love of liberty, his social government, are all less or more tinctured by the nature of the physical characteristics of the country he inhabits.

285. That such is the case, the most cursory glance at the different nationalities of the world will readily convince; and though the inherent qualities of Race, for reasons we cannot now discover, may differ very widely, still over and above these qualities external conditions exert a direct and perceptible modifying influence. The white men of Europe may differ physically and intellectually from the black tribes of Africa and the red races of North America; but it may be fairly questioned whether the former would have ever exhibited their present activity and progress had it not been for the greater varieties of surface, climate, and general physical conditions that Europe, as a continent, enjoys. There can be no doubt that the moderate climate of Britain is more favourable to bodily and mental vigour than the relaxing temperature of the tropics; and that the slight seasonal differences between our spring, summer, autumn, and winter, induce habits of continuous exertion and industry unknown in countries subjected to excessive summer's heat and winter's cold. But for our insular situation, our countrymen would never have been the traders and adventurers they have become; and but for our natural supplies of coal, iron, and other metals, the mechanical and manufacturing character that now stamps the British nation would have been unattainable and impossible. So much does the general character of a people depend upon the physical conditions of the country they inhabit!

286. Even in their minor peculiarities, the different nations of the same great race are similarly affected by external conditions: hence the obvious distinctions existing between the livelier and more versatile nations of southern Europe and the graver inhabitants of the north; between the bold and independent mountaineers of Switzerland, Scotland, and Scandinavia, and the tamer occupiers of the central and eastern European plain. Climate, food, landscape—all, in fact, that constitutes geographical diversity—must exercise an influence on mental as well as on bodily character; and were it not so, there is reason why the inhabitants of one country should not be identical in all their aspects with those of another. The language of everyday life, however, is full of such distinctions, and this long before science had attempted their explanation. Thus we speak of the "dry, clear, exhilarating air" of one district, and the "damp, cloudy, and depressing atmosphere" of another: of the "dreary monotony" of one region,

and the "charming variety" of another; of the "awe-inspiring gloom" of the forest, and the "cheerful hues" of the open landscape. Indeed it is to the influence of situation that we are in a great measure to look for national peculiarities—these peculiarities diminishing the more that nations extend their range of intercommunication, and the less they are restricted to their own narrow boundaries.

Characteristics and Distribution of Race.

287. Whatever the influence of external conditions in modifying the characteristics of race, we find Man distributed at present over almost every region of the globe—wandering in savage freedom under the tropics, flourishing in busy communities within the temperate zones, and struggling in diminished numbers against the inclemencies of the polar regions. Within the tropics he is chiefly a vegetable feeder; in the temperate zones he adopts a mixed vegetable and animal diet; while within the polar circle his diet is exclusively animal. But while in this respect he obeys, like plants and animals, the zonal arrangements of the world, unlike them the varieties of his race are distributed according to no law of latitudinal dispersion. As in districts of the same country we find differences of stature, physiognomy, dialect, and habits; so in the various countries of the same continent we find still wider differences in bodily appearance, mental constitution, language, and manners. Notwithstanding these well-known distinctions, there is among the inhabitants of certain regions a certain sameness in physical aspect, in colour of skin, in form of head and face, and also in mental disposition, that stamps them as distinct from the inhabitants of other regions; hence arises the idea of *varieties* or *races* of the human species. That these varieties or sub-species (for the difference seems greater in some instances than what zoologists consider a variety) have existence in nature, we have only to look at the condition of mankind, as at present scattered over the surface of the globe. Here, active, intelligent, and progressive; there, sluggish, dull, and stationary: here, enjoying the highest amenities of civilisation; there, grovelling in a condition little elevated above the brutes by which they are surrounded. And not merely do they differ in intellectual qualities, but in physical organisation, in mien and stature, in form of head and expression of face, in colour of skin, in strength and endurance, and, in fine, in all those purely bodily qualities by which one species of animal is distinguished from another.

288. Without entering upon the vexed questions of man's origin and antiquity,—whether he is a mere development from the lower animals, according to some great natural plan, or an entirely new creation—whether he has been six or sixty thousand years an inhabitant of the earth — and whether the varieties of our race have descended from a single pair, and been since modified by external conditions, or are the progeny of several independent pairs,— it may be stated as the general opinion of naturalists that mankind (as they now exist) form, in the zoological scale, a single species of a single genus. But though thus standing unique, and far exalted above other animals by his gifts of reason, moral perception, and religious sentiment, it is necessary and natural to divide mankind into several varieties according to their more prominent physical features; and Ethnology (Gr. *ethnos*, a race; *logos*, a discourse), extending the subject to minor features, language, and the like, still further subdivides these varieties into groups, tribes, and branches. The consideration of these minor distinctions (which are evidently produced by intermixture of races and the influence of external conditions) belongs more especially to Ethnology; our limits will merely permit a brief allusion to the *five* varieties or races into which the inhabitants of the globe have been arranged by the German philosopher, Blumenbach. These are the *Caucasian*, the *Mongolian*, the *American*, the *Ethiopian*, and the *Malay;* each being characterised by some peculiarity in colour of skin, eyes, nature of hair (curled, lank, woolly, frizzled), shape of skull, form of face, and general physiognomy. Of these physical characteristics colour of skin is one of the most obvious, and, though varying in shade even in the same race, is yet employed in everyday language as a main mark of distinction—the Caucasian being the *white*, the Mongolian the *yellow*, the American the *red*, the Ethiopian the *black*, and the Malay the *brown*. The distribution and more obvious characteristics of these respective races we epitomise from Blumenbach and other ethnologists:—

289. The *Caucasian* variety is dispersed over Turkey, Arabia, Persia, part of Tartary, Affghanistan, and Hindostan, in Asia; over Egypt, Abyssinia, and the Mediterranean seaboard, in Africa; and over almost the whole of Europe—the Turks proper, the Magyars, Finns, and Laplanders, being of Mongolian origin. Within the last three centuries the race has spread from Europe over large areas of North and South America, South Africa, Australia, and New Zealand (see Ethnographic Map in Atlas); and wherever it has planted itself becomes the dominating power. This variety takes its name from the Caucasian mountain-range

1, Caucasian; 2, Mongolian; 3, Ethiopian; 4, Malay; 5, American.

that stretches between the Caspian and Black Sea, because tradition points to that region as the place of its origin; and it is also known by the term *Indo-European*, from its spreading over India and Europe from the Ganges to the farther shores of Iceland. The more important branches are the Hindoo, Persian, Arab, Circassian, Slavonic, Teutonic, and Celtic, with their various mixtures and alliances, which now constitute the nationalities of southern Asia and Europe. Of course, thousands of years have passed away in the development of these respective branches—each branch springing out from its predecessor, and assuming new features in body, mind, language, and beliefs according to the nature of their new region, though still retaining enough of the original stock to mark their origin and descent.

290. The distinguishing characteristics of these Indo-Europeans are—a light-coloured skin, varying from fair to tawny or swarthy; red cheeks; copious, soft, flowing hair, generally curled or waving; ample beard; small, oval, and straight face, with features distinct; expanded forehead; large and elevated cranium; narrow nose; and small mouth. In stature the Caucasian is taller than any of the other varieties; of erect gait; with rounded, well-proportioned limbs; moderately small extremities; and light, elastic step. The *White* race (for by this designation it is generally distinguished) has given birth to the most civilised nations of ancient and modern times; and has hitherto exhibited the intellectual and moral powers of human nature in their highest degree. Wherever the white man has established himself, the other races disappear before him. His proper field of development, however, seems to be the temperate zones in either hemisphere, for beyond them he degenerates physically and intellectually, and loses the higher characteristics of his race. And even as regards the whole species, it is held by some that "Man presents to our view his purest, his most perfect type at the very centre of the temperate continents—at the centre of Asia-Europe, in the regions of Iran, of Armenia, and the Caucasus; and, departing from this geographical centre in the three grand directions of the lands, the types gradually lose the beauty of their forms in proportion to their distance, even to the extreme points of the southern continents, where we find the most deformed and degenerate races, and the lowest in the scale of humanity."

291. The *Mongolian* variety is spread, as the name implies, over the central and northern regions of Asia, China, Japan, Burmah, Siam, and Cochin-China; and includes, moreover, the scattered inhabitants of the Arctic seaboard, both in the Old and New World continents. It embraces the Mongols, Turks, Tibetans,

Chinese, Indo-Chinese, Japanese, Kamtchatdales, Tungusians, Koriaks, and Samoiedes, in Asia; the Turks, Finns, and Lapps, in Europe; and the Esquimaux of the North American arctic regions. In the Mongolian the skin is olive-yellow; the hair thin, coarse, and straight; little or no beard; head or cranium somewhat square-shaped; forehead rather low; face broad and flattened, with confluent features; high cheek-bones; eyes rather sunk, and obliquely directed towards the nose; wide and small nose; and thick lips. In stature the Mongolian is below the Indo-European; but in the true Tartar, Turk, and Chinese, the frame is broad, square-set, and robust, with high shoulders, and short and strong neck.

292. In intellectual and moral capacity the various branches of the race differ very widely; but on the whole they are inferior, less energetic, and more stationary in their civilisation than the Caucasian variety. "With the Mongol," it has been remarked, "the melancholic temperament seems to prevail; the intellect, moderate in range, exercises itself upon the details, but never rises to the general ideas or high speculations of science and philosophy. Ingenious, inventive, full of sagacity for the useful arts and conveniencies of life, it nevertheless is incompetent to generalise their applications. Wholly turned to the things of earth, the world of ideas—the spiritual world—seems closed against him. His whole philosophy and religion are reduced to a code of social morals limited to the expression of those principles of human conscience without the observance of which society is impossible." Socially and morally, the highest attainments of the race appear in the Chinese and Japanese, the Turks and Magyars having been so long amalgamated with Europeans as to assume a Western rather than an Oriental phase of civilisation.

293. Under the *American* variety, ethnologists comprise all the aboriginal races which peopled the New World prior to its discovery by Columbus in 1492. These are the Chippewyans, Sioux, Pawnees, Cherokees, and other tribes in North America; and the Caribs, Solimoes, Guaranis, Araucanians, Patagonians, and Fuegians in South America. In this race the skin is reddish or copper-coloured (hence the familiar designation of Red Indian); the hair is black, coarse, and lank; beard scanty; skull somewhat similar to the Mongolian, but narrower, and not so square; forehead low and retreating; cheek-bones prominent, but more rounded than those of the Mongol; eyes sunk, and somewhat raised at their outer angle; nose and other features rather prominent. In stature the North American Indian is rather tall; spare and lithe in body; and as a hunter, acute in his senses, and

remarkable for his endurance of fatigue and insensibility to pain In South America the race greatly degenerates; the Guaranis, the Fuegians, and other tribes being amongst the most degraded of savages, their wretched appearance being in many instances aggravated by artificial distortion of the head and facial features.

294. In intellectual and moral qualities the American Indians resemble in many respects the Mongolians. Like the Mongols, they have remained stationary, but at a much lower point of civilisation, if we except the ancient occupants of Mexico and Peru, whose geographical position seems to have imparted to them a greater degree of energy and activity. In North America the race is rapidly disappearing before the white settlers; in South America, less fitted for the White, the inferior and more sparsely scattered tribes have been little interfered with. "The indigenous man of America," says M. Guyot, "bears in his whole character the ineffaceable stamp of the peculiarly *vegetative character* of his country. Living continnally in the shadow of those virgin forests which overspread the earth that he inhabits, his whole nature has been modified thereby. The very copper hue of his complexion indicates that he lives not, like the negro, beneath the scorching sunbeams. His lymphatic temperament betrays the preponderance in his nature of the vegetative element. The Indian is of a melancholy, cold, and insensible race. Foreign to our hopes, our joys, our griefs, it is rarely that a tear moistens his cheek, or a smile lights up his eye. The most barbarous tortures cannot extort from him a single complaint, and his stoical indifference is disturbed only by vengeance or jealousy. If he sometimes exhibits a display of prodigious muscular force, he is yet without endurance. . . . . The social condition of the Indian tribes is hindered, in an equal degree, by the powerful influence of his vegetative character. The Indian has continued the man of the forest. He has seldom elevated himself above the condition of the hunter, the lowest grade in the scale of civilisation. The exuberance of the soil has never been of value to him, for he asks not of the earth his nourishment. He has never even ascended to the rank of the pastoral man. With him no domestic animals are maintained to feed him with their milk, or clothe him with their fleeces, as they are by the nomadic races of the Old World. From one to the other extremity of America we find the same lamentable spectacle; the people of the elevated table-lands of Mexico and Peru are the only exceptions to this picture, and this exception goes far to establish the influence of the vegetative and humid nature of the lower plains of America."

295. The *Ethiopian* race, in one or other of its branches, in-

habits the whole of Africa, with the exception of Egypt, Abyssinia, Tunis, Tripoli, and Morocco on the north, and Cape Colony on the south. It embraces Hottentots, Bushmen, Kaffirs, Negroes, Gallas, Tibboos, Mandingoes, and other tribes, differing widely among themselves in physical and mental aptitude, but all, from time immemorial, remaining in a barbarous or but very partially civilised state. In this variety, which derives its name from the Ethiopia of the ancients, the skin is black (hence the familiar designation, Negro—Lat. *niger*, black); the hair short, black, and woolly; skull compressed on the sides, and elongated towards the front; forehead low, narrow, and slanting; cheek-bones very prominent; nose broad and flat; jaws projecting so as to make the upper front teeth oblique; lips, especially the upper one, very thick. In stature there are great differences among the different branches of the race—some, like the Kaffir, being of average size and fairly formed; others, like the true negro, also of average size, but ungainly in form and limb, with large, flat feet and hands, and shuffling, awkward gait; and some, again, like the Hottentot and Bushmen, of stunted stature, and with slender, ill-formed limbs. Intellectually, the Black race has ever remained in a rude and barbarous state; hence the subjection of one branch to another branch among themselves; and hence, also, their enslavement, from time immemorial, by the white variety. This is not the place to enter upon the question, how far the negro is capable of attaining the higher phases of civilisation; but the fact remains, that neither of himself, nor in any of his admixtures with other races, has he shown much aptitude for intellectual or social advancement. Even in the fine genial clime of the highlands of equatorial Africa, as described by Captain Speke, the negro remains much the same—easy, indolent, sensual, enslaving or enslaved, but never rising to the higher conceptions of social or moral polity, and still less to the attainments of science or philosophy.

296. The *Malay* race (so called from the Malayan peninsula) includes the widely-scattered and chiefly insular inhabitants of Malaysia, Australasia, and Polynesia. The population of these widely-spread districts differ, as might be expected, very widely from each other—those of Malaysia and Polynesia being of a brown or lighter colour, and somewhat resembling the Mongolians; while those of New Guinea and Australia (the Papuan negroes, as they are termed) are of a dark colour, and more closely approximated to the negro type. Intellectually, also, there is a similar difference, there being little in common between the Malay of the Indian Archipelago and the savage inhabitant of New

Guinea; between the stunted and miserable native of Australia, and the daring, apt, and clever inhabitant of New Zealand; or between the calculating nature of the New Zealander, who lives under a temperate climate, and the mild, facile, and careless character of the true islander of the sunny Pacific. Taken, however, as described by ethnologists, the skin of the Malay varies from a light tawny to a deep-brown; hair black, crisp, and somewhat inclined to curl in the true Malay, and tufted and frizzled in the Papuan; head rather narrow; bones of the face large and prominent; nose full and broad towards the lips. In civilisation the Malay race has hitherto made little advancement. In the Indian Archipelago it has, like the Mongolian, long remained stationary; in Polynesia, some progress appears under tutelage of the white, though the areas are apparently too small and too widely separated ever to be of much importance; in New Zealand it seems reluctant to amalgamate with the new settlers; while in Australia it is rapidly dying out before the encroachment of the European immigrant.

297. Taking these varieties as aids to the *general* arrangement and consideration of mankind, it must be remembered that there are not only admixtures among conterminous races (Caucasian and Mongol, Mongol and Malay, Mongol and American), but admixtures also between immigrant and native races (Brazilians, Peruvians, Mexicans, &c.), which render sharp lines of demarcation impossible, and unnecessary as impossible. The consideration of these *minutiæ* belongs more especially to Ethnograpy and Philology, by which not only shades of colour, types of skull, facial angles, and the like, are taken into account, but dialects of language, mental peculiarity, and forms of government, are all considered in tracing the dispersion, affinities, and history of the human race. Such considerations lie beyond the scope of our Outline, and the student of physical geography may consider as sufficient for his purpose the *five* great varieties above enumerated, or even their abridgment into *three* (Caucasian, Mongolian, and Ethiopian)—reckoning the American as a sub-variety of the Mongol, and the Malay a sub-variety partly of the Mongol and partly of the Negro. It is the general features merely that our science aims at; the details of nationality, of language, and the progress of civilisation belong to History, Ethnology, and Philology, and would require volumes for their special treatment and elucidation. And even as regards these sciences, it must be confessed that many of their conclusions are fanciful and unsatisfactory, and must remain so till mankind are considered more in a Natural History point of view, and less as a being apart from the other relations,

physical and vital, of the universe. Anthropology, or the natural history of man, treated as the natural history of any other animated being, is a study that has scarcely yet received a name and place among the other branches of human knowledge.

Conditions of Civilisation and Progress.

298. Such is the usual subdivision of mankind into varieties or races, and such the existing distribution of these races over the surface of the globe. The subdivisions may to some extent be arbitrary; but as there are actual differences of colour, form of head, facial expression, and the like, and as these physical features are accompanied by strongly-marked differences in mental constitution, in form and structure of language, and in intellectual capability, the distinctions in the main must be founded on nature. As to the prehistoric distribution of man, neither archæology nor geology, in the absence of reliable remains, can arrive at any certain conclusion. Within historical time, however, the various races, while peopling most densely the regions they now occupy, have ever been less or more encroaching on each other's domain—the inferior giving way to the superior and more civilised. The Ethiopian, in its numerous tribes and branches, has remained stationary in Africa. The Malay, chiefly an insular race, has spread itself, in one or other of its branches, over the islands of the Southern Ocean and Pacific. The Mongolian, while claiming Central and Eastern Asia as its headquarters, has spread partially into Europe, and largely along the entire seaboard of the Arctic Ocean. The White man, on the other hand, has partly repelled the Mongol, and, after spreading wave after wave over Western Asia, Northern Africa, and the whole of Europe, has within the last three centuries taken possession of the greater portion of North America (United States, Canada, Mexico, California, &c.); of part of South America (Brazil, Guiana, Peru, &c.); of South Africa; and of Southern Australia and New Zealand; while his influence is felt, less or more, in every region of the globe.

299. Wherever the means of subsistence can be obtained, there man will establish himself and increase in numbers—his increase being mainly regulated by the facility or difficulty of obtaining supplies. Where he can raise more than his own wants require (and this will depend very much on his knowledge of nature's laws and operations, or, in other words, on the natural capabilities of Race), or where he enjoys products not possessed by other localities, this surplus and these products form subjects of barter

and exchange, and thus he acquires wealth and the power to command luxuries. Raised above the mere physical struggle for existence, the higher faculties of his mind—imagination, invention, reflection, moral perception, and religious sentiment—begin to develop themselves, and man passes from the domain of savagery into the categories of civilisation. To trace the course of civilisation lies beyond the scope of our subject; but it is evident, from what has been repeatedly stated, that its advancement (laying altogether aside the consideration of Race) depends, in a great measure, on the geographical or physical conditions by which it is surrounded. Wherever there exists a favourable climate, the means of subsistence, and opportunities of interchange and barter—in other words, wherever there are the objects and means of successful industry—there civilisation will manifest itself; and just as equitable laws, protection of property, freedom of action, and liberty of opinion are enjoyed, so civilisation will advance in a corresponding ratio. In absence of these adjuncts it has passed, and may yet pass, from nation to nation; but in the aggregate its maintenance from epoch to epoch has been secure—its progress seems illimitable.

300. It may be noted, however, that, other things being equal, a maritime or oceanic population will more readily excel in civilisation than a continental or inland one—their progress being directly as their means of interchange and intercommunication with other countries. Again, a population like that of China, enjoying vast and equable geographical conditions, will remain more stationary than another even of the same race (as the Japanese) who possess more limited but more varied surroundings. Further, populations cut off from intercommunication by land-barriers, such as vast deserts and mountain-chains, remain more isolated and less progressive than others separated by the widest oceans; hence the sharp definings of certain Asiatic races, such as those of China, India, Tartary, and Arabia. Still further, variety of external conditions and variety of natural products necessarily produce greater contrasts, greater activity, and greater intelligence; hence the varied and superior civilisation of a diversified continent like Europe compared with the other great sections of the globe. In fine, the effect of geographical condition and consequent industry is too often lost sight of in our social and political reasonings; and it may be laid down as an axiom, that no great continent possessing different climates, different products, and necessarily different pursuits, can possibly be governed by the same laws, or permanently united under the same forms of government.

NOTE, RECAPITULATORY AND EXPLANATORY.

In the preceding chapter attention has been briefly directed to the varieties and distribution of the human species—Ethnology or Ethnography being the science which treats of these distinctions. It has been shown that Man, though possessing a greater elasticity of constitution than most of the lower animals, and capable of enduring under almost every climate, is still, to a great extent, influenced by the external conditions by which he is surrounded, both in his physical and mental relations. Whether owing to these influences, or arising from aboriginal differences which science cannot explain, Man now appears in several *varieties* or *races*—each occupying well-marked territories on the globe, and distinguished by peculiarities of colour, form of head, facial expression, and other *physical* features, as well as by equally obvious *intellectual* and *social* qualities. These varieties are the *Caucasian* or *white*, the *Mongolian* or *yellow*, the *American* or *red*, the *Ethiopian* or *black*, and the *Malay* or *brown*—each embracing a great number of tribes, branches, and nationalities, differing in language, social polity, and other peculiarities.

The Caucasians, or Indo-Europeans, inhabit the south-western section of Asia, the northern belt of Africa, and nearly the whole of Europe, and have, in modern times, extended their dominion to large areas of North and South America, South Africa, South Australia, and New Zealand. The Mongolians, concentrated chiefly in Central and Eastern Asia, have partially penetrated into Eastern Europe, but are most extensively spread in scattered communities along the entire seaboard of the Arctic Ocean. The Malays, having their headquarters in Malaya and the Indian Archipelago, are spread, in one or other of their tribes, over Australia, as well as over all the island groups that stud the bosom of the Pacific. The Ethiopians, through drafted hither and thither as the slaves of the white man, have been mainly stationary in Africa, the natural home and habitat of their race; while the Americans, or Red Indians, have been equally restricted to the New World continent. As a whole, the negro and Red Indian have made, and still make, the least progress in civilisation; hence their easier subjection by the higher races, and hence also their rapid disappearance before them. The Malay and Mongolian come next in order; and though some of their sections (Chinese, Japanese, &c.) have arrived at considerable eminence in the industrial arts, yet in both races the essentials of higher progress seem wanting, and hence their torpid and stationary aspect. By the white race alone do we find displayed the higher efforts of bodily and mental activity—hence in ancient times the civilisations of India, Assyria, Palestine, Egypt, Phœnicia, Greece, and Rome; and in modern times those of Western Europe—Austria, Germany, France, and Britain; of the United States and Canada; and, generally, of our colonies, in whatever region of the globe they may happen to be established.

The conditions favourable to this civilisation are partly of a geographical or physical nature, and partly intellectual; and wherever the two are in fortunate conjunction, there the progress of the white race is certain, and illimitable as certain. We say of the *white* race, for as yet neither of the other varieties have at all approached the standard of his civilisation in temperate zones. Indeed it may be fairly questioned, on psychological grounds, whether they are naturally capable of the same kind and degree of social, moral, and intellectual attainments; and also whether, in all the temperate and sub-tropical regions at least, they are not in time destined to disappear before the spread and progress of the white, or to be imperceptibly absorbed into his superior numbers and advancement. Under the equatorial zone—and be it observed that only a very small portion of the land-surface is strictly equatorial, and even of that portion a considerable share, like the highlands of equatorial Africa, Mexico, and Colombia, are capable of being inhabited by the white man—the black and brown races, in some of their offshoots, may rise to a subordinate civilisation; but everything we know of the past points to illimitable progress in the white, and to a limit and declension in the other varieties of our species.

The student desirous of entering more minutely into the study of Ethnology and its kindred branches, may consult such works as those of Dr Prichard, Dr Latham, Messrs Gliddon and Nott, Mr Brace, and others, along with the plates and letterpress in the 'Physical Atlas' of A. K. Johnston.

XVI.

GENERAL REVIEW, APPLICATIONS, AND DEDUCTIONS.

Objects and Principles.

301. THE object of Physical Geography being not only to describe the external aspects of the world, but to determine the causes by which these aspects have been, or are still in course of being, produced, it has been necessary, in the preceding chapter, to deal with principles as well as details. Indeed, the aim throughout has been to present our planet as subjected to general laws, believing that, when these are understood, there will be little difficulty in comprehending their modifications in local and limited areas. Let the student clearly understand the origin, for example, of winds and rains, of tides and currents, and he will soon find his way to determine the causes that produce their modification in any special locality. Let him once comprehend the main causes of climatic diversity, and the manner in which it affects the distribution of plants and animals, and he will have no difficulty in accounting for the peculiar climates of individual countries, or for the plant-life or animal-life by which they are peopled. The great object in an outline like the present is to inculcate principles; the details of geography would require volumes for their enumeration.

302. In accordance with these views, attention has been directed to the planetary relations of the earth—its figure, motions, dimensions, &c.—as on these depend its light and heat, its alternations of day and night, summer and winter, and, in general terms, all that gives rise to change and diversity in its external conditions. It is, in fact, to its solar relations that the earth owes, if we may so speak, its life and activity, deriving therefrom *directly* its rotation, revolution, heat, light, seasonal differences, and tides; and *indirectly* its winds, waves, and currents, its rains, snows, and frosts—all that produces diversity in the distribution of its plants

and animals, and change in the geological relations of its rocky exterior. It was necessary, also, to consider the individual structure and composition of the globe, and the geological changes which, under the operation of aqueous, igneous, and meteoric forces, that structure has been and is still undergoing. On these forces depend the distribution of sea and land, the formation of highland and lowland, the production of soils, and all those exterior aspects which influence so decidedly the character and localities of the plants and animals by which it is peopled.

303. Seizing upon the present terraqueous aspects of the globe, and regarding its geological changes as only appreciable at long and distant intervals, the more immediate province of our science was to investigate the relative distribution of its lands and waters, the disposition, highlands and lowlands of the one, and the configuration, depth, waves, tides, and currents of the other. Understanding the relations of land and water, and their necessary actions and reactions on each other, attention was next directed to the atmosphere by which both are surrounded, through which the light and heat of the sun are diffused to both, by which the plant-life and animal-life of both are sustained, and in which are elaborated the winds, rains, frosts, snows, and other phenomena that constitute the essentials of weather and climate. This all-encircling atmosphere is the great bond of union between land and water, between plants and animals, equalising and regulating the heat and moisture of the former, and conveying and supplying the vital gases so indispensable to the life and growth of the latter.

304. The consideration of this earth revolving through space as part of the solar system, composed superficially of land and water, surrounded by an atmosphere, and receiving heat, light, and other influences from the great central orb, constitute what may be termed the *physical* or *inorganic aspects* of geography. On the other hand, the study of the earth as peopled by plants and animals, and inhabited by man, capable of applying the whole to his own social and moral advantage, form its *vital* or *organic features.* In other words, the one relates to the *Physics* of the earth, and includes considerations merely of a mechanical and chemical nature; the other to its *Life*, and involves the more intricate problems of physiology and psychology. The study of the vital world, the distribution of its plants and animals, the causes concerned in that arrangement, and the dependence of the one kingdom on the other, becomes, therefore, one of the most attractive themes in geography. Still higher, however, and of more immediate interest, is that which deals with our own race—their physical and mental peculiarities, their dispersion over the globe, and

the question how far geographical conditions and the pursuits incident thereon may influence their social, mental, and moral progress.

305. But our science has its practical as well as theoretical importance, its economic as well as its scientific aspects. A knowledge of the distribution of sea and land—the winds, tides, and currents of the one, the highlands, lowlands, and climate of the other, and the mineral, vegetable, and animal products of both—is indispensable to successful navigation, commerce, and agriculture. The duty of determining the earth's mineral, vegetable, and animal products, and how far they can be rendered available for the purposes of everyday life, is not less imperative than the solution of its physical and vital problems. It is of vast importance to be acquainted with the character, abundance, and accessibility of nature's products, but it is not less important to learn how to apply them. All knowledge of nature is good of itself, but its value is doubly enhanced when it is made to minister to our common humanity. Combining, therefore, its theoretical with its practical bearings, and remembering that every country is characterised by its own natural products, and has consequently something that no other country can supply, Physical Geography has paramount claims alike on the attention of the philosopher, the statesman, the sailor, the farmer, the merchant, and manufacturer.

306. The material wealth of the globe—that is, the products derivable from the mineral, vegetable, and animal kingdoms, and capable of being employed so as to administer to the comforts and luxuries of life—forms the leading theme of economic geography. Every country, in virtue of its geological age and formation, has some special mineral or metal in greater or less abundance; and every region, in virtue of its position and climate, produces vegetables or animals peculiar to its own area. Man's ingenuity is ever on the rack for new inventions in the arts and manufactures; and as all his raw materials are drawn from one or other of the realms of nature, he turns to Physical Geography for indications of the character, abundance, and accessibility of the products that belong to the different countries of the globe. This search produces commerce, commerce brings about communion between the most widely diverse and separated regions, and this communion is the main incentive to civilisation and human progress. In this way Britain draws the raw materials of her manufactures from every accessible portion of the globe, returning thither her manufactured goods, and thereby creating new wants, new activities, new ideas, and all, in fine, that arises from the

contact between superior and inferior civilisations. If the inferior, in consequence of its lower organisation and inaptitude, cannot be acted upon by, or amalgamate with, the higher, it gradually disappears and makes room for the development of those higher conditions which seem to be the natural and destined end of the human species.

307. Such, in general terms, is the aim and scope of physical geography—to describe the lands and waters of the globe, the atmosphere by which they are enveloped, the mutual actions and reactions established between the elements in virtue of the planetary connections of the earth, the plants and animals by which they are respectively peopled, and finally, man's dependence on, and relationship to, the whole. In considering these phenomena, and in endeavouring to ascertain their producing causes, the geographer regards them as all under the operation of fixed and determinable laws. No appearance, however rare, no set of phenomena, however intricate, but must be the result of natural laws; and the highest theme of his science is the discovery of these laws, and the resolution of the whole into one harmonious cosmos. But while he mainly deals with the existing aspects of nature, he cannot lose sight of the fact that these aspects are continually undergoing change and modification in virtue of the great operative forces of the universe. These changes may be all but imperceptible even for centuries; but, in process of time, they become sufficiently apparent, and stamp new features on the external contions of the globe. The air and water, ever wearing and wasting the rocky surface in one district and collecting the eroded material in another—the earthquake and volcano, elevating the solid crust in one region and depressing it in another—are ever changing the relative positions of sea and land; and thus the seas and lands of the future must differ from the seas and lands of the present, as those of the present differ from what geology assures us existed in time past. Every change of the external relations of sea and land, whether of distribution or of elevation and depression, implies a corresponding change in the nature and distribution of plants and animals; and here, again, the life of the future must differ from that of the present, as the present differs from that revealed to us by the researches of the geologist.

308. In this way the student of physical geography must regard the earth and all its relations—physical and vital—as in a state of incessant change and progress. The changes may be slight—so slight as to pass unobserved for generations—yet still they are not on that account less real or certain. Bearing these facts in mind,

we can more readily comprehend why the rocks (the old sea-sediment) of one region should differ from those of another, why the mountain aspects of the one should differ from those of the other, and why one tract should be low and alluvial while another is high and rocky—each feature being the product of a certain time and change in the earth's relations. In this way, too, we can understand the gradual formation of deltas, of sand-dunes along shore, of coral-reefs in mid-ocean, of the shoaling of certain seas and lakes, and the changes of plant-life and animal-life incident upon such alterations of habitat. History records the uprise of some sea-coasts and the depression of others, the appearance of new islands and the outbursts of new volcanoes, the increasing rarity of certain forms of life or their entire extirpation, the disappearance of certain forest-growths and the succession of others in their place, the extinction of certain aboriginal races of men and the spread of others over the same areas—changes which would often appear inexplicable but for this law of incessant mutation and progress. It is also by bearing in mind this great feature of ceaseless change that we can account for the similarities and differences that exist between the flora and fauna of different regions—regions that may at one time have been continuously connected by land, though now widely separated by expanses of ocean. The plants and animals of Britain, for example, claim kindred with those of Europe, and this through land-connections that existed long before their separation by the Strait of Dover. It is, in fine, by carrying this idea of mutation into all our reasonings, that physical geography becomes a more intelligible part of World-history—connecting the past with the present, and preparing the philosophic mind for the nature of the changes that must ensue in the inevitably approaching future.

309. As formerly stated (Chap. III.), the chief agents concerned in the modification of the earth are the winds, rains, frosts, and snows elaborated in the atmosphere, which are ever loosening and disintegrating the exposed rocky surface; the streams, rivers, waves, tides, and ocean-currents, which are incessantly wearing and wasting and re-depositing the eroded materials along the bottom of the sea; and the earthquake and volcano, whose operations are alike incessant in upheaving and depressing the crust—now raising the sea-bed into dry land, and now submerging the dry land beneath the waters. No doubt, the consideration of these agencies belongs more especially to geology; but their results bear so directly on the arrangement and moulding of the terraqueous surface, that they cannot possibly be overlooked by the geographical observer, either in his descriptions or in his determination of

the laws upon which all geographical phenomena are dependent. Some idea of the magnitude of their combined influences may be formed by reflecting on the number of streams and rivers that are ever coursing over the earth's surface, and cutting out for themselves ravines, glens, and valleys; on the extent of coast-line exposed to the degrading action of waves and tides and currents; and on the areas in Iceland, Italy, Central Asia, Indian Archipelago, Philippine, Japan, and Aleutian Islands, Mexico, West Indies, Andes, and the Pacific islands (see Map of Volcanoes, p. 97), that are subjected to earthquake and volcanic disturbance; to say nothing of those areas like Scandinavia, Siberia, Arctic America, &c., that are undergoing the slower processes of gradual elevation or depression.

310. Notwithstanding these continual operations, their results, for any limited time, do not greatly affect the general relations of the earth; and thus the geographer is enabled to depict, within appreciable limits, its existing aspects in an intelligible and available form. It is this intelligible account of existing appearances, and the causes concerned in their production, that constitutes the sum and substance of our science; and just as this account is founded on correct observation and harmonises with sound induction, so the more rapidly will Physical Geography attain to perfection. As has been eloquently remarked by M. Guyot, "it is not enough for it coldly to *anatomise* the globe by merely taking cognisance of the arrangement of the various parts which compose it; it must endeavour to seize those incessant mutual actions of the different portions of physical nature upon each other—of inorganic upon organised beings, upon man in particular, and upon the successive developments of human societies; in a word, studying the reciprocal action of all these forces, the perpetual play of which constitutes what may be called the Life of the Globe, it should, if I may venture to say so, take up its Physiology." Understanding it in this light, the scheme of nature becomes invested with new interest, its various portions assume new harmony and unity, and man, in his physical, social, and moral development, stands in a clearer and closer relationship to the whole.

311. Bearing in mind the principles of the science as thus described, and the general laws by which the various domains of nature are held in cosmical harmony, we may now proceed to apply them in a brief explication of the respective continents or quarters of the globe which form the theatres of human action and enterprise. If the general principles are sound, they find their best illustration in the details of the minor sections, and, at all

events, can be best understood in their applications to special instances. In this way a brief analysis of the respective continents may be useful to the general reader as well as to the student, and the law which was perhaps but slenderly understood may find more thorough comprehension by its application to particular instances that may come under the notice of the local observer. These minor sections are Europe, Asia, Africa, North America, South America, and Oceania—each presenting features and phenomena peculiarly its own, but all readily intelligible and in perfect harmony with the general principles laid down in the preceding chapters.

Continental Aspects—Europe.

312. Applying the principles laid down in the preceding chapters, we find that Europe lies almost wholly within the northern temperate zone, and, in consequence, will be mainly influenced in its climate, life, and industry by this great primary condition. Its limits are usually comprehended within the 36th and 71st degrees of N. latitude, and the 10th degree of W. and 64th of E. longitude; but its bounding line is rendered so irregular by the indentation of seas and gulfs, and the projection of peninsulas and promontories, that an idea of its configuration can be best obtained by a study of the Atlas. Its area, as already stated, is estimated at 3,725,000 square miles, of which about 317,500 belong to its islands and islets. Within this area there is every diversity (within ordinary limits) of surface; and it is this diversity that confers on Europe its especial character as compared with any other of the continents. Devoid of immense plains like those of America, it is not marked by the same uniformity of vegetable and animal life that characterises the New World; and wanting in those vast deserts and plateaux that occupy so much of Asia and Africa, it is not marked by those strong contrasts and separations that belong so peculiarly to the greater portion of the Old. Everywhere with diversity of surface there is the most intimate connection, and thus it possesses a compactness—a unity in its variety, if we may so phrase it—that is not to be found in any of the other continental land-masses.

313. Notwithstanding this unity of conditions, it must be remembered that the mountain-systems of Europe (Chap. VI.) lying chiefly in the south, confer on its southern section an irregular and hilly aspect; while the northern section, from the German Sea inwards through the Netherlands, Prussia, and Russia, is generally flat, or but little interrupted by elevations or depressions. We

have thus a southern region characterised by its mountains, table-lands, and intervening valleys; and a northern (Chap. VII.) marked by a predominance of pasture-plains, heathy wastes, lakes, and morasses. Unless in the extreme north, the greater proportion of the surface is more or less improved and under cultivation; and though large tracts are still occupied by natural forest, heath, sandy waste, lake, and morass, yet, on the whole, the natural aspect of Europe has been much more modified by man than that of any other continent. In other words, the natural conditions of its soil and climate have been more interfered with by man's operations than those of any other region, and in a corresponding degree, also, the plants and animals by which it was originally peopled. It is the great headquarters of civilisation, commerce, and cultivation; and thus, in all our reasonings on its geographical conditions, the modifying influence of man must be taken into account as an important and pervading element.

314. Geologically, Europe presents illustrations of every system, from the crystalline schists to the most recent alluvia, and from the deepest-seated granites to the latest volcanic eruptions (see Map in Atlas). From the broken and undulating nature of the country, these formations are repeatedly brought to the surface in all the northern and western districts—northern and eastern Russia being the only region where formations are continuous over extensive areas. In this way the mineral and metallic treasures of Europe become more readily available; and these consist, in general terms, of granites, porphyries, marbles, limestones, gypsum, rock-salt, sulphur, sandstones, fire-clays, pottery-clays, alum-shales, sands, flints, and other mineral substances used in the arts and manufactures; of iron, copper, tin, lead, silver, mercury, manganese, zinc, antimony, and other metallic ores; of gold and platinum, though less profusely than in some other regions; and of most of the precious or ornamental stones, with the exception of the diamond, Oriental ruby, and some varieties of the sapphire. This abundance and availability of the useful minerals and metals enabled her inhabitants to engage at an early period in arts, manufactures, and commerce; and it is to this same abundance and availability that her present superiority in mechanical, manufacturing, and commercial industry is mainly attributable. From the absence of great rivers, and the paucity of volcanic centres, the existing geological relations of Europe are undergoing comparatively little change—the gradual uprise of the Scandinavian coast, the alluvial formations at the mouths of such rivers as the Po, Rhine, Danube, and Dnieper, and the alternate inroads and sand-silts of the Atlantic, being the only appreciable phenomena.

315. As might be expected from the position, configuration, and surface-diversity of Europe, its climate is also varied and variable, without participating in those violent contrasts which mark most of the other continents. Lying almost wholly within the northern temperate zone (only a fourteenth of its area being within the arctic circle), a very small portion is uninhabitable on account of cold, while even on its most southern limit the heat is by no means excessive. The mean temperature of its southern border is about 66 degrees; and at Cape North, in lat. 71°, it is 32 degrees—a mean fully equal to what is experienced in North America between the parallels of 55° and 56°. On the whole, its mean temperature is higher than that of other regions within the same parallels, while in no part is it subjected to the same extremes of winter cold and summer heat. In fine, the climate of Europe partakes more of an *insular* than of a *continental* character; and this arises mainly from the circumstance that she is surrounded on three sides by the sea, and otherwise indented by inland seas and gulfs, so that no extensive portion of her surface is far removed from the tempering influences of the ocean. Besides this, her western shores are laved by the current of the Gulf Stream, which not only brings an additional store of heat, but wards off the cold approach of the northern iceberg; while the draining of marshes, clearing of forests, and other efforts of cultivation, have also tended to improve the climatic character of the country. The fact, also, that the lower part of Europe lies towards the north and the higher to the south, is not without its influence in modifying the climate; for had this been reversed—that is, had the Alps, Pyrenees, and Carpathians been situated in the north—more than a third of the surface would have been perpetually under snow and glacier and the rest would have been periodically chilled by their proximity.

316. Arranging the surface into climatic zones, the three following regions are usually enumerated:—1st, The *warm region*, where the lemon, orange, fig, olive, myrtle, and vine flourish, extending to the 45th degree of north latitude, and having a pleasant spring, a hot summer, and short mild winter. The countries within this belt have generally abundant rains during the last three months of the year, but are subject to great and long-continued droughts in summer. 2d, The *temperate region*, extending in the islands and seaboard to 55° north latitude, but in the interior perhaps not beyond 52°. In this region frost prevails two, three, or four months, and snow is common; the spring continues from April till June; the summer, the heats of which frequently rise to 92° Fahr., last till September; and the autumn is the shortest season. 3d, The *cold region*, to the north, in which,

beyond the 65th parallel, only two seasons occur—summer and winter; the former lasting during June, July, and August, and the latter during the rest of the year. In this region the heat, during the brief summer, when the sun never sets, is very great, and the cold during the long winter proportionally severe.

317. In consequence of the principal mountain-chains being situated in the southern or warmer region, the climatic effects of altitude are less striking than in many other regions, though, as seen in Chap. XIII., the Alps and Pyrenees show various belts of vegetation, especially in their higher ridges. As the snow-line in Europe makes a very gentle curve from about 8500 feet in the Alps to 2000 feet at the North Cape, only very limited patches in the Alps and Dovrefelds come within its limit; and hence, also, these are its only mountain-ranges that exhibit the phenomena of *glaciers*. As might be expected, the western side of Europe is the most humid, the number of wet days on the Atlantic seaboard averaging from 150 to 160 annually; the southern or Mediterranean side is next in order, and averages from 90 to 100 days; while in the centre and eastern districts a much smaller proportion (from 60 to 80) is experienced. On the whole, the climate of Europe is variable, but not excessive—fickle, but not insalubrious; calling forth the utmost skill and watchfulness on the part of the husbandman, but never wholly disappointing his hopes or defeating his labours.

318. As might be expected from this diversity of climate, as well as from the diversity of physical aspect formerly alluded to, the vegetation of Europe presents considerable variety and complication—a complication which is greatly enhanced by the long-continued introduction of plants, useful and ornamental, from other regions. Referring to Chap. XIII. for matters of mere botanical interest, we may here briefly enumerate the range and limits of those fruits and vegetables that have more especially a useful or economic bearing. The dwarf-palm, cactus, and banana are found skirting some of the warmer portions of the Mediterranean seaboard. From this point north to the 45th parallel, the orange, citron, fig, pomegranate, olive, almond, myrtle, laurel, cypress, mulberry, vine, &c., flourish in perfection—some of these, as the vine, being profitably cultivated in sheltered valleys, so far as the 50th degree. From the 45th to the 55th, the apple, pear, plum, cherry, apricot, and smaller garden-fruits are abundant; and in the southern, middle, and western districts, as far north as the 60th parallel, the plane, chestnut, walnut, poplar, oak, ash, elm, beach, and other forest-trees, attain to perfect growth; as do also wheat, barley, rye, oats, beans and pease, beet, turnip, and

other bulbous roots, the potato, flax, and common cultivated grasses. In the central and eastern regions, where the climate is more decidedly *continental*, these plants find their limits at the 50th and 52d parallels, even in the lowest valleys. Forests of pine and birch continue in luxuriance as far as the 67th degree; at the 70th, oats and barley are the only kinds of grain which resist the rigour of the climate, though not always ripening; and beyond this the dwarf-birch and willow, the iceland and reindeer moss constitute the principal flora.

319. From the densely-peopled and cultivated character of Europe, its fauna (in all the larger animals at least) may be re-regarded more as a domesticated than a natural one. The true natural fauna is varied enough in point of species, but not important in point of size or number, and, with the exception of those (the white bear, blue fox, reindeer, lemming, &c.) restricted to its arctic section, can inhabit indifferently any part of the country. This moderate climate, and the absence of great mountain and desert barriers, give a uniformity to the fauna of Europe which is not observable in other continents; and this uniformity is greatly augmented by the circumstance that the larger and more destructive animals are all but extirpated. But while the moderate and equable conditions of Europe have been unfavourable to the preservation of the native fauna, they have been specially favourable to the spread and crossing of the domesticated—and thus improved and improving breeds are to be found in every portion of its surface. Devoid of the larger carnivora and reptiles, of the brilliantly-coloured birds and insects that belong to warmer latitudes, the continent of Europe preserves, in an eminent degree, the elements and facilities for the cultivation of the useful and agreeable. In this way, partly from native and partly from exotic stocks, have arisen the many and valuable varieties of the horse, ass, ox, sheep, goat, and pig; of poultry—peacock, turkey, guinea-fowl, barn-fowl, swan, goose, duck, pigeon, &c.; and in a less degree also of game birds, such as the grouse, ptarmigan, partridge, capercailzie, and pheasant. In this way, too, the temperate seas of Europe are stocked with inexhaustible supplies of wholesome fish, shell-fish, and crustacea, of which the cod, ling, tusk, haddock, turbot, sole, skate, salmon, sturgeon, tunny, herring, pilchard, mackerel, oyster, crab, and lobster, are among the most abundant and valuable.

320. On the whole, the geographical conditions of Europe,—its varied surface, numerous seas, and extensive sea-coast—its climate, mineral, vegetable, and animal productions,—eminently fit it for developing the enterprise and industry of its inhabitants.

And this development has been further fostered by the fact that all the finer southern and western portions are peopled by the more energetic Indo-European or Caucasian race, while the eastern and northern (or least valuable sections) are inhabited by families of Mongolian descent. Into the numerous families and tongues which time and the influence of external conditions have evolved from these two races, our limits will not permit us to enter; but it may be remarked that the Celtic, Teutonic, and Slavonian are the predominating sub-varieties—each embracing a vast number of minor nationalities and tongues, which are still acting and re-acting upon each other in production of newer, and, on the whole, advancing stocks. The causes that regulate the growth and decay of nationalities is yet imperfectly understood; but however much may be ascribed to the inherent physiological peculiarities of race, there can be no doubt a vast amount depends upon the geographical or physical conditions of situation. In this respect the inhabitants of southern, central, and western Europe have had important advantages; and hence their superior civilisation, their progress in the arts and manufactures, and in all that relates to mechanical and commercial industry; and hence, also, their spread over a large portion of the New World and Australasia, whose aboriginal races seem destined to disappear before them.

Asia.

321. This anciently-peopled continent is by far the most extensive and diversified, the most compact in point of configuration, and yet, paradoxical as it may seem, the most widely separated in the character of its parts, of any of the so-called "quarters" of the globe. Situated between lat. 1° 28′ and 78° north, and long. 26° and 190° east, it occupies the greater portion of the eastern hemisphere, and presents an area estimated at 16,165,000 square miles, or more than four times that of Europe. A considerable portion of this is insular and peninsular, but not to such an extent as to interfere materially with the massiveness and continuity of configuration to which we have referred. Occupying three great climatic belts—tropical, temperate, and arctic—and exhibiting vast mountain-chains and lofty table-lands, broad grassy steppes and shingly deserts, luxuriant river-plains and tracts doomed to everlasting snow or scorching sterility, it is impossible to treat the continent as a whole, and hence it is usual to arrange it into northern, central, western, eastern, and southern sections—each having well-marked and distinctive features.

322. 1. Northern or Russian Asia, as observed in a former treatise, includes the whole of the continent north of the Altai and Yablonnoi Mountains—a region (as we descend from the mountains) of rocks and forest-growth, steppe-land and frozen tundra, bleak and barren, suffering from intense cold, thinly peopled, and almost physically incapable of improvement. Steppes affording a rough pasture in summer, and here and there capable of a rude cultivation; forests of pine and birch, gradually dwarfing to the north and east; and tundra or bog-moss frozen for ten months a-year, and scarcely thawed to a foot in depth during a brief summer, are the leading features of this inhospitable section. 2. Central Asia, lying principally between the 30th and 50th parallels, embraces the lofty table-lands of Gobi, Mongolia, Tibet, and Eastern Tartary—a region of sandy deserts and salt lakes, diversified by mountain-knots that rise above the snow-line, and occasionally intersected by narrow valleys of considerable amenity. As the northern section was the region of frozen, so the central is the region of arid deserts, with this difference, that the more southerly position of the latter confers on its deeper valleys both verdure and fertility. 3. Western Asia, still exhibiting a series of plateaux, and partaking of the desert character of the central region, but less elevated and more broken up by hill-ranges and intervening valleys. On the whole, it is a hot and thirsty region, consisting largely of high sandy plains studded with numerous salt lakes, and but inadequately watered by rivers. The steppes of Western Tartary, the table-lands of Persia, and the deserts of Arabia, belong to this region—the finest portions being Turkey in Asia, Georgia, and the plains of the Tigris and Euphrates. 4. Eastern Asia, or that embracing the Chinese Empire, Mandshuria, and the islands of Japan, is one of the finest and most diversified sections of the great continent. The mountains of China and Mandshuria give to its western and northern portions an irregular and varied aspect, but its eastern consists of the great Chinese plain and low-lying region of vast extent and fertility. 5. Southern Asia, including Hindostan, Farther India, and the Malayan peninsula, and lying largely within the tropics, is decidedly the richest and most diversified region of the whole. Varied by minor hill-ranges and well-watered valleys, by deltas and river-plains, it enjoys a high though not oppressive temperature, has only a rainy season for its winter, and, except during long droughts in Central Hindostan, presents in every district an unfailing verdure.

323. The geological features of regions so vast and varied must necessarily partake of corresponding diversity; and though the geology of Asia is but imperfectly known, we have gathered enough

from recent surveys and travels to confirm the belief that every formation is there displayed, and this frequently on a most gigantic scale. Partaking of the arctic uprise of land in Siberia, having large rivers with gradually increasing deltas like those of the Indus, Ganges, and rivers of China, and being subjected in a remarkable degree to volcanic and earthquake disturbance in almost all its islands, as well in several parts of the mainland, its geological relations must be undergoing considerable modification, but not at such a rate as to interfere, for generations perhaps, with its general features. All the economic minerals and metals are found within one or other of its countries; the precious metals and gems also occur in abundance; and though less noted for its coal and iron than Europe or North America, it has still enough, in India, China, and Japan, to form the basis of a successful mechanical and manufacturing industry.

324. A continent stretching over three great geographical zones —tropical, temperate, and arctic—must necessarily exhibit great diversity of climates; and this diversity is rendered still more remarkable by the lofty table-lands, arid deserts, and snow-clad mountain-masses that occupy so large a proportion of the central regions. On the whole, as we have elsewhere observed, the continent of Asia does not enjoy the same modifying and tempering influences as Europe. A large proportion is situated on the confines of the polar circle, where, according to Von Wrangel, the winter's ice is gradually accumulating and overmastering the summer's heat; a still larger section is raised to an enormous altitude, and placed permanently under snow and glacier; its mass lies comparatively unbroken by intersecting and tempering seas; it has no burning sandy tracts in the south to send warm breezes, as the Sahara does to Europe; the Japan Current, whose genial waters lave its eastern coast, is of minor volume compared with the Gulf Stream; and even its southern or tropical districts are cooled by the winds that flow from the snow-clad central mountains. It suffers, therefore, what Humboldt calls an *excessive* climate—that is, excessively hot in summer and excessively cold in winter, or differing greatly during these seasons from the mean annual temperature. In other words, while the climate of Europe is more insular than continental, that of Asia is strictly and emphatically continental. As instances of its extremes, it has been remarked that grapes come to maturity on the borders of the Caspian, and yet the thermometer falls there in winter to 28° Fahr.; that at Tara, in Siberia, the temperature of the air in July and August rises to 82°, while a foot under the surface the soil remains permanently frozen; that in Arabia, after a night of hoar-

frost, the day-heat will often be as high as 114° Fahr.; that the snow-line in the Elburz is found at 11,000 feet, while in Tibet the mountains are clear at an elevation of 16,000 feet; and that while all the great central deserts are all but rainless, the annual rain-fall in the lower plains of India amounts to 400 or 500 inches.

325. With a position so extensive, a contour so decided, and a climate so varied, we might naturally expect an abundant and diversified life, and in this respect, both vegetable and animal, Asia stands unrivalled among the other continents. If excelled in vegetable luxuriance by tropical America, it has at least greater variety of forms, while its animal life has a physiological power and completeness unapproached by other regions. Referring to Chap. XIII. for the general features of its vegetation, as governed by the great climatic zones, we shall here merely allude to those products which, like tea, are either peculiar to its soil, or which, from their value, become of industrial and commercial importance. Among its *fruits* may be mentioned the grape, orange, shaddock, lemon, lime, tamarind, mangosteen, fig, mulberry, olive, pome-granate, walnut, almond, cocoa, date, bread-fruit, cashew, betel, banana, pine-apple, melon, quince, apricot, peach, and all the garden fruits known in Europe; among *grains* and cultivated *roots*, maize, rice, wheat, dhourra, barley, pease, beans, lentils and other leguminous seeds, potato, yam, lotus, arrow-root, &c.; among *spices* and kindred products, cinnamon, nutmeg, clove, pepper, camphor, cassava, tea, coffee, sugar, sago, &c.; among *drugs, dye-stuffs, fibres*, and the like, indigo, arnatto, saffron, gam-boge, galls, poppy, rhubarb, aloes, gums, hemp, jute, cotton, and many others; while among the *forest* and *ornamental trees* may be noticed the teak, cedar, sycamore, cypress, savin, mangrove, bam-boo, banyan, plantain, cocoa and other palms, along with ebony, iron-wood, box-wood, sandal-wood, and others of a kindred nature.

326. It has been remarked by Guyot, that "as in the New World the vegetable kingdom has the preponderance over the animal, so in the Old World the animal has the preponderance over the vege-table. Not only are the representatives of the corresponding families larger and stronger in the Old World, but they appear in more numerous genera and more varied species, and even exhibit types entirely foreign to the New." In accordance with this opinion, it might naturally be expected that Asia, the largest and most diver-sified of the Old World continents, should have a fauna of corre-sponding variety and power; and thus it is that in all the zoolo-gical classes (with the exception, perhaps, of the reptiles and in-sects which dominate in tropical America) its animals excel both in nobleness of form and in numbers. Among the *mammalia*

may be noticed the apes and monkeys of the south; the lion, tiger, leopard, panther, ounce, and other felinæ of the south and west; the elephant, rhinoceros, and tapir of India; the wolf, hyena, jackal, blue and black fox, and numerous varieties of dog; the horse, ass, dzigettai, and camel of the central and western plains; the common ox, buffalo, auroch, yak, and musk-ox; the elk, reindeer, antelope, axis, argali, ibex, goat, sheep, mufflon, &c.; porcupine, jerboa, marmot, lemming, beaver, bat, ermine, &c.; together with bears, badgers, gluttons, sea-otters, seals, sea-cow, and other cetacea. As her mammalia excel in variety, so also they excel in utility; and from Asia, as the original source, have other regions derived most of their domesticated and semi-domesticated animals, as the horse, ass, camel, elephant, ox, goat, sheep, pig, dog, cat; peacock, pheasant, barn-fowl, and other creatures so necessary to the comfort and luxury of civilised communities. Her seas, lakes, and rivers are stocked with valuable food-fishes, though less notably than Europe; red coral, mother-of-pearl, and pearls are fished from her gulfs; and among her special insect-products may be noted her silk, honey, bees-wax, cochineal, gall-nuts, lac, and other kindred substances.

327. Ethnologically the continent of Asia is occupied by three main varieties of mankind—the Caucasian, Mongolian, and Malay; the first inhabiting the south and west, the second the north and east, and the third the south-western region and adjacent Archipelago. Though each of these varieties embraces a vast variety of families and tongues—Hindoos, Persians, Syrians, Arabs; Chinese, Japanese, Mongols, Tartars; Burmese, Javanese, Polynesians—yet, on the whole, the physical peculiarities of the continent have kept them wonderfully apart, and thus each has enjoyed its own peculiar civilisation for ages. How little has China and Japan been influenced by India; how little has the civilisation of Japan reflected on Malaysia; and though Tartar and Kalmuck inroads from the north have been frequent enough on the south, how little impression, save that of destruction, have they left on the plains of Persia or the deserts of Arabia! Mountains and deserts form barriers more impassable than seas; and thus, altogether apart from the physiological peculiarities of the Mongolian and Malay races, there has been none of that action and reaction, that domination and absorption, that commingling and evolution of higher stocks, that has marked the progress of mankind across the continent and along the seaboards of Europe. The civilisations of Europe have been more maritime than continental; those of Asia more continental than maritime. The one, in minor areas and along varied seaboards, has had a tendency to develop social

and complex relations; the other, in vast areas, and chiefly on far-separated river-plains, has been more productive of isolation and stationary individualism. "What has been wanting to the communities of Asia," it has been well remarked, "is the possibility of actions and reactions upon each other, more intimate, more permanent; it is the possibility of a common life. On the other hand, the smallness of the area, the near neighbourhood, the midland seas thick sown with islands, the permeability of the entire continent—everything conspires to establish between the European nations that community of life and of civilisation which forms one of the most essential and precious characteristics of their social state." It is thus that civilisation in Asia stands still or declines, while in Europe it is ever active and progressive.

Africa.

328. The next great "quarter" of the Old World is that of Africa, having an estimated area of 11,360,000 square miles, or, including Madagascar and the other islands, of 11,855,000. It lies between the parallels of 37° N. and 34° 50′ S., and between long. 17° 30′ W. and 51° 30′ E.; being thus mainly tropical, and having only its northern and southern borders within warm-temperate latitudes. Separated from Europe by the Mediterranean, and but slenderly united to Asia by the low Isthmus of Suez, which is only 72 miles across, it is all but insular, and has consequently little of that community which marks the relations of Europe and Asia. The continuity of its coast-line is almost unbroken by seas, gulfs, or estuaries, and this resisting solidity of form is no doubt the chief cause of its interior being less known than that of any of the other continents. Even the disposition of its rivers is unfavourable to its penetration. The largest of them flow within its equatorial limits, and either debouch through swampy jungles, which is death for the white men to enter, or descend by cataracts and waterfalls inaccessible to navigation.

329. So far as we know of the physical peculiarities of the continent, it may be divided into four or five regions—differing in physical structure, but less in climate and vital aspects, than the regions of any of the other continents. Beginning with the north, we have—1st, The mountainous district of the Tell lying between the Mediterranean and the Sahara, and composed largely of the Atlas chain, with its subordinate spurs and intervening valleys. Where the hills decline towards the Atlantic in Marocco the district is somewhat flat, but, generally speaking, it is hilly and irre-

gular, with a warm but salubrious climate towards the Mediterranean, and a dry scorching one on the north, where it insensibly graduates into the Sahara. 2d, The region of the Sahara or Great Desert, which stretches from Marocco on the west to the Nile valley on the east—a hot and arid expanse, consisting partly of shingly plateaux resting on gypsum and largely impregnated with salt, and partly of dunes or ridges of drifting sand, the whole being marked at intervals by *oases* or fertile spots that enjoy the presence of a spring or runnel of water. The Sahara has thus its fertile and inhabited oases, its scrubby plateaux, and its shifting dunes of utter sterility. Its general character, however, is aridity and barrenness, and the oases merely appear like islets of verdure amid an ocean of desert. 3d, The Atlantic-coast region, a belt of luxuriant but unhealthy lowland, marked by numerous deltas and jungles along shore, but gradually rising and improving towards the interior. This region is rich in tropical forest-growth and verdure, but its pestilential climate has hitherto resisted all European approach, unless at a few very limited and unsatisfactory stations. 4th, The Southern or Cape region, which rises by successive hill-stages towards the north or unknown interior—these stages forming irregular terraces which are covered with grass after the rains, but become hard and bare, or but partially dotted with thorny scrub, during seasons of drought. On the whole, this region is hilly and irregular in surface, has a salubrious but arid climate, is by no means well watered by rivers, and is occasionally subject to destructive droughts. 5th, The Central region, which, so far as we can judge from recent discovery, partakes of the character of a high table-land, having numerous lagoons and creeks during the rains ; but is wanting, on the whole, in rivers of permanent volume and navigable channels. Though strictly tropical, the elevation of this table-land confers on many portions the climate of temperate zones; and where water is present the country is described as fine and fertile, well peopled, and partially under a rude cultivation. The 6th and last region is that skirting the Red Sea, and comprising the hilly but not unfertile table-land of the Galles and Abyssinians, the more stony and arid country of Nubia, and the alluvial valley and delta of Egypt. This region is remarkable for its fine but somewhat arid climate; its fertility where water is present ; and, ethnologically, for the early and peculiar character of its civilisation.

330. Geologically we know little of the formations of Africa, and hitherto the continent has contributed less to the mineral and metallic wealth of the civilised world than any other region. The whole of the Sahara is but the upheaved bed of a tertiary, or even

quaternary ocean; the deltas of the Nile, Niger, and other great rivers, consist of recent alluvia; the formations of the Cape are chiefly mesozoic sandstones; the northern belt consists largely of soft tertiary limestone; the primary hills of Abyssinia and Nubia are known chiefly for their granites and porphyries; and most of the islands, whether in the Atlantic or Indian Ocean, are of recent volcanic origin. The great interior is unknown, but, judging from conformation as well as from native ornaments and report, iron, copper, gold, and silver must exist in its mountains.

331. As already observed, the greater portion of the continent lies within the tropics, and must necessarily partake of the climate peculiar to the torrid zone. The Cape region and the region of the Tell are the only parts enjoying warm-temperate or sub-tropical conditions, and even these are more or less influenced by the excessive climate that pervades the interior. "It is only that strip of Barbary," says Balbi, "which the Atlas protects from the hot winds of the desert, and that part of Hottentotland protected by the Nieuveldt and other mountains near the Cape, that enjoy the advantages of countries situated within the temperate zones. With the exception, therefore, of these small and narrow tracts, of those regions in the interior to which their elevation imparts the coolness of higher latitudes, and of the borders of the great lakes and rivers (see Captain Speke's experiences, 173), every part of Africa is burnt up by continual heat, and the continent generally may be regarded as the warmest region of the globe. Nothing moderates the heat and the dryness but the annual rains, the sea-winds, and the elevation of the soil; while in the well-watered regions, the moisture combined with the heat, though productive of the most luxuriant vegetation, are extremely deleterious to man."

332. As might be expected from the tropical position and generally hot and arid climate of Africa, its vegetation is more unique and much less varied than that of Europe or Asia. Along the Mediterranean seaboard and the lower valley of the Nile, the vegetation greatly resembles that of southern Europe, with a greater tendency, perhaps, to tropical forms. Wherever soil and water can be obtained, rice, maize, wheat, lentil, and millet; the grape, orange, fig, olive, and date; cotton, flax, and tobacco, can be grow to perfection, and often, as in Lower Egypt, yield large returns. The Sahara, where vegetation is possible, is characterised by its prickly shrubs, brooms, pistachios, tamarisks, ephedras, and dry tufty stypa grass, while in its oases the date-palm is the indispensable product, having, as the Arabs say, "its feet in water and its head in fire." In Upper Egypt and the highlands of Nubia and Abyssinia, the characteristic plants are gum-yielding

acacias, the cassia or senna shrub, coffee, ginger, turmeric, cardamoms, melon, lotus or jujub, the nelumbium or water-lily; and the cultivated ones, maize, lentil, and millet. The Cape region, as might be expected from its arid soil and climate, is distinguished for its heaths, proteas, pelargoniums, mesembryanthemums, stepelias, crassulas, euphorbias, aloes, cactuses, thorn-apple, mimosa, and prickly shrubs; and at the same time yields profitably such plants as have been introduced by the settlers, as vines, currant-grape, orange, pine-apple, peaches, apricots, pears, apples, and other garden fruits; together with rice, cotton, tobacco, tea, and coffee. In the central parts of the continent the vegetation, of course, is strictly tropical—palms of many species, banyan, adansonia, banana, dragon-tree, papaw, tamarind, sugar-cane, cotton-tree, tallow-tree, maize, manioc, yam, ground-nut, melon, and the like, being the native produce; while in the islands (Mauritius, Madeira, &c.), the vine, lemon, orange, melon, coffee, and sugar-cane can be grown to perfection.

333. Like the other continents of the Old World, Africa possesses a numerous and diversified fauna, though from its greater uniformity of climate, its almost insular position, and the absence of vast intervening barriers, there is a greater sameness or community between its different regions. It has also several forms peculiar to itself, though, remarkable enough, these forms are found fossil in the more recent tertiaries of Europe and Asia. The tropical forests abound in apes, monkeys, and baboons; the larger felinæ (lion, panther, leopard, &c.) roam almost from one end to the other of the continent, as do also the hyena, jackal, and their congeners; antelopes, in numerous species, are nowhere so abundant; it possesses also, in a special degree, the Cape buffalo, camel, dromedary, giraffe; the horse, zebra, dauw, quagga; the elephant, rhinoceros, hippopotamus, and species of river-hog; cetacea (whales, seals, dolphins) are all but unknown in its waters, but many of the smaller mammals, hyrax, porcupine, ant-eater, pangolin, jerboa, &c., are peculiar and numerous. Among the birds of Africa may be mentioned eagles, griffins, vultures, and other birds of prey; ostrich, bustard, guinea-fowl, quail; flamingo, pelican, secretary-bird, crane, ibis; parrots, parroquets, and others of brilliant plumage; cuckoo, swallow, nightingale, canary, and the like, which are only known to us as summer visitants or household captives. Though numbering among her reptiles, turtles, crocodiles, monitors, lizards, chameleons, &c., Africa, as a tropical country, is by no means rich in serpents; and though her seas and rivers abound in fish, yet in food-fishes she falls far behind the sister-continents of Europe and Asia. Her insects, too

(locust, white-ant, scorpion, tzetze-fly, &c.), are chiefly destructive or troublesome; and she possesses few or none, like the silkworm, cochineal insect, and bee, of commercial utility.

334. The inhabitants of Africa (laying aside English, Dutch, Portuguese, and other European settlers) belong chiefly to the Semitic branch of the Caucasian variety in the north, and wholly to the negro or Ethiopian variety in the central and southern regions. The Semitic or Syrio-Arabian stock embraces the Egyptians or Copts, the Abyssinians, Nubians, Arabs, Berbers, Moors, and other families arising from their admixture; the Negro variety embraces, on the other hand, the whole of the dark-coloured races—Gallas, Fellatah, Jalofes, Mandingoes, Krus, Ashantees, Congos, Zulus, Kaffirs, Hottentots, Bosjesmen, &c.—that people the continent from the Sahara to the Cape. Unless within the European settlements, civilisation in Africa is at a very low ebb. The Moors and Arabs, though active traders, are but in a state of semi-civilisation: their manufactures in silk, cotton, linen, leather, and the like, are rude; and their commerce, carried on chiefly by caravan, is limited and uncertain. The negro races, on the other hand, though some tribes indulge in barter, others keep herds, and some again attempt a primitive agriculture, are not, as a whole, raised beyond the level of barbarism. The inherent qualities of the race are evidently inferior; and whether it is capable of amalgamating with the white, of being taught and elevated by its example, or is doomed ultimately to disappear before it, are problems yet to be solved by the ethnologist. On the whole, the habitat of the true Negro seems to be strictly intertropical; under its fiery sun he is robust, hardy, and lively; beyond it he becomes enfeebled, and degenerates. The heat, however, that develops the Negro enervates the white, and this circumstance may yet reserve for the race an equatorial zone in which it may attain to a limited and semi-dependent civilisation.

North America.

335. This great section of the New World bears much the same relation to the western hemisphere that Asia-Europe does to the eastern; while South America holds a somewhat analogous position to Africa. Like Europe and Asia, North America lies chiefly within the northern temperate zone; has its coast-line well diversified by bays, gulfs, peninsulas, and promontories, and has also numerous outlying islands. South America, on the other hand, lies, like Africa, mainly within the tropics; is also slenderly united

to the North by a narrow peninsula; has a coast-line little broken by indentations; and has, in like manner, fewer and less important islands. Unlike the Old World, however, the trend of whose main mountain-masses are latitudinal, the New World has its mountain-chains arranged longitudinally; and this disposition, of course, confers on its surface many important distinctions, both physical and vital. On the whole, the continent of North America enjoys temperate position, extent of coast-line, ready access to its interior by bays, lakes, and rivers, and at the same time comparatively easy communication between all its parts, from the absence of impassable deserts or insurmountable mountain-barriers.

336. Physically, the continent may be arranged into the following regions, the nature of which, with slight modifications, are thus given by Malte Brun and Babli:—1. The narrow region of Central America, which lies between the Gulf of Mexico and the Pacific, and is traversed throughout its whole length by mountain-ranges, which leave but a strip of low land along the sea-coasts, while in certain portions of the interior they form (par. 86) elevated table-lands. This region is strictly intertropical, and, along with the West India Islands, is marked by a tropical flora and fauna, unless in the more elevated portions of the interior. 2. The maritime region, extending from the extremity of the Californian peninsula northwards to Aliaska, and from the shores of the Pacific inland to the ridge of the Sea Alps. This region has a fair climate, but is hilly, irregular, and cut up by numerous cross-gorges from the mountains. 3. The elevated region which forms a sort of table-land between the Sea Alps on the west and the Rocky Mountains on the east. In its southern portion it presents the arid salt plains of the Californian desert; between 40° and 45° north it presents a somewhat fertile desert; but beyond the last-mentioned parallel it becomes barren and inhospitable. 4. The great central plain of the Missouri and Mississippi (par. 94), extending from the Rocky Mountains on the west to the Alleghanies on the east, and from the Gulf of Mexico northward to the 50th parallel. On the west this region is rich and well wooded; in the middle it is open or rolling prairie-ground, but not unfertile; but towards the west it is dry, sandy, and almost a desert. 5. The eastern declivities of the Alleghany Mountains and the maritime region, extending to the shores of the Atlantic. This is a region of natural forests, of mixed but rather poor soil, and with considerable tracts of swamp-land in the south. 6. The great northern plain beyond the parallel of 50°, dotted on its southern limits by pine-forests, but beyond this, for four-fifths of its area, a bleak and desolate waste, overspread with numerous lakes, and resem-

bling Siberia in the physical character of its surface and the rigour of its climate. 7. To these may be added (though not belonging to the American continent) the frozen region of Greenland and the Arctic islands—a division of the globe doomed to perpetual snow, ice, and glacier, and whose wealth arises more from the temporarily open seas that surround it, than from the land of which it is composed.

337. Geologically, this continent presents every stratified formation, from the old crystalline schists of St Lawrence and the Appalachians down to the recent alluvia of the Mississippi, and from the granites, syenites, and porphyries of the Rocky Mountains down to the recent ejections of the Mexican volcanoes. The great central plain, from the delta of the Mississippi north to the Arctic Ocean, is chiefly of recent origin, and consequently yields comparatively few mineral or metallic treasures ; but in the other regions the economic minerals are numerous and abundant. Of these may be mentioned—granite, and building-stones of every description ; limestone, marble, magnesian limestone, and gypsum ; salt and salt-springs in great abundance, and from several formations ; coal, both anthracitic and bituminous, in inexhaustible fields in the United States and Nova Scotia ; asphalte, pitch, and petroleum springs ; roofing-slate, whet-slate, and other minor minerals. The chief metals are—gold in California, British Columbia, Mexico, and the Carolinas ; silver in the Central States and Mexico ; iron in the United States, Canada, Mexico, and other districts ; copper abundantly in the United States, Canada, and the far north ; lead also abundantly in the Western States and Canada ; and tin, mercury, and antimony in Mexico.

338. As will be seen by a glance at the sketch-map of isotherms, the climate of North America is greatly inferior to that of the Old World within corresponding parallels of latitude. The great extent of surface that lies within the arctic zone, the solidity of its mass, unbroken by the tempering influence of seas, the flow of the arctic current that chills so much of its eastern seaboard, the amount of forest and undrained lands, and the cold aërial currents that pass from the frozen lake-region of the north over the interior, all conspire to diminish the temperature that normally belongs to its geographical position. This diminution is usually stated to be about 10° Fahr., as compared with the temperature of the same parallels in the west of Europe. The western or Pacific seaboard, however, is much warmer than the eastern on the same parallel ; but this influence is little felt beyond the ridges of the Sea Alps, and does not tend to mitigate the northern air-currents that reduce the temperature of the interior. Altogether,

North America possesses a true continental climate—severe winters and warm summers; and from this circumstance it has been supposed that it will be impossible to carry the arts of civilised life much beyond the 56th or 58th parallel, latitudes within which are situated the capitals of Norway, Sweden, and Russia.

339. Compared with the Old World, the New World excels in the exuberance of its vegetation. The breadth of its plains, the humidity of its atmosphere, and its rich and well-watered soil, confer on it a verdure—a "leafness," as it has been termed—not to be found in the flora of the Old. From the Isthmus of Panama north to the 27th parallel, the vegetation (with the exception of that on the higher table-lands) is altogether tropical; and hence all the low grounds of the West India Islands and Central States teem with the products of that zone.* From the 27th north to the 35th parallel is the warm-temperate zone of the continent, marked by its magnolias, swamp-hickories, lobelias, deciduous cypress, and luxuriant climbers and aquatics; and between the 35th and 44th parallels may be said to lie the true temperate zone, characterised by its oaks, ash, hickory, plane, white cedar, sasafras, cornel, yellow birch, red maple, fine flowering climbers and aquatics, and growing in perfection all the cultivated fruits and grains. North of the 44th parallel to the basin of the St Lawrence and Canadian lakes stretches the colder-temperate zone, with its oaks, elms, birches, maples, red and white pines, and the ordinary fruits and grains of temperate Europe; while northward and beyond lie forests of pine and fir, that gradually give place to the dwarf willows and birches of the arctic regions. In an economic or agricultural point of view, it may be stated that all the common garden fruits of Europe can be reared in the northern states of the American Union; while oranges, pomegranates, melons, figs, peaches, grapes, olives, almonds, &c., can be grown in the south. Indian-corn is cultivated all south of Maine, tobacco as far north as 40°, cotton to 37°, the sugar-cane to 32°, rice in the Gulf States, wheat all over the Union, oats and rye chiefly in the north, and hemp, flax, and hops in the western and middle districts.

* "The rich and varied productions of the West Indies," says a recent authority, "give them an important place in the commercial world. To their valuable native plants, art and industry have added others not less valuable. The sugar-cane, yielding its threefold tribute of sugar, molasses, and rum; the coffee-plant, pimento, or allspice; the plantain and the banana; the pine-apple, anona, yam, sweet-potato, maize, cassava, manioc, with cacao, tobacco, and cotton; various dye woods and stuffs, as fustic, logwood, indigo; medicinal plants, as liquorice, arrow-root, ginger, jalap, ipecacuanha; building and cabinet timber, as mahogany, lignum vitæ, and cedar; to which list may be added the bread-fruit, cocoa, mango, papaw, guava, orange, lemon, tamarind, fig, and other tropical fruits."

340. It has been already stated that while the New World excels in the exuberance of its vegetable forms, it falls far behind the Old in the variety and importance of its animals, the reptiles and insects alone excepted. Many of the higher forms are altogether wanting, others are but feebly represented; while, generally speaking, there is a greater paucity of specific variety even in the forms that occur. Whatever may have been the condition of the New World during geological times, it is certain that since the current era it had no native horse, ass, zebra, or other equine species; no giraffe, camel, or dromedary; no elephant, hippopotamus, or rhinoceros; no useful ruminants comparable to those of Europe and Asia; and though the puma, jaguar, and ocelot may represent the lion, tiger, and leopard, there is a feebleness and want of numerical abundance even in these, as compared with feline and carnivorous animals of Asia and Africa. Besides these, other Old World forms have their representatives, but still inferior in power and numbers—as, for example, the camel by the llama, the marsupials of Australia by the opossums, the ostrich by the rhea, the crocodile by the alligator, and so on of other orders. In like manner the monkeys of the New World are inferior to those of the Old; the native red man also is less robust, less hardy, and less lively than the black man of the Old; and thus, while the latter has thriven and multiplied even under toil and oppression in the New, her own aborigines have dwindled and died at the sight of industry and application. From the proximity of the continents perhaps, there is a stronger resemblance between the fauna of North America and that of Asia-Europe than there is between those of South America and Africa, though both are chiefly tropical; and hence such forms in the north as the Esquimaux dog, the lynx, wolf, fox; polar, black, and grisly bears; badger, otter, beaver, ermine, bison, elk, reindeer, moose, red, and other deer. It is chiefly from this cause that all the domestic animals of the Old World—horse, ass, camel, ox, sheep, goat, pig, dog, cat, poultry, and the like—have been introduced with such success in North America, and have spread with the colonists over every habitable region of the continent.

341. Referring to Chap. XV. for the characteristics of the aborigines of the New World—the American or red variety of mankind —we may here remark that at the time of its discovery in 1492, North America was inhabited chiefly by *Indian* tribes, who led a savage life, and obtained their subsistence by hunting and fishing, having neither herds nor flocks, nor even attempting the rudest forms of agriculture; by the *Aztecs*, a civilised offshoot of the race who inhabited the Mexican table-land, and had made

considerable progress in the arts; and by the *Esquimaux* (of Mongolian descent), who peopled, as they do now, the shores of the northern seas, and subsist wholly by fishing. Since then the continent has been colonised and peopled principally by Europeans (we exclude the African negroes imported as slaves, and their half-breed progeny), Spaniards in Mexico and the West Indies, French along the St Lawrence and Mississippi, British, Dutch, and Germans originally along the eastern seaboard, but now over the whole habitable surface, insular and continental. From these, and from their admixtures, have arisen what may be termed the Anglo-American family, before whose advance the native tribes are rapidly disappearing, and who, carrying with them and still enjoying all the advantages of European civilisation, are gradually laying the foundation for newer phases of progress, in conformity with the special conditions of their continent. We say *phases*, for the continent is too large, and its geographical conditions and consequent industry too diversified, ever to be governed by a single and uniform rule; and in all likelihood before many generations pass away, Mexico, the Pacific States, British America, the New England States, the Gulf or Southern States, and the Great Central Plain, will each be the seat of an independent community—connected, it may be, by commercial ties and reciprocating international offices, but still individually influenced by their position, and progressing at different rates and in different ways, and this in a great measure according to the nature of their material surroundings.

South America.

342. United to North America by the narrow Isthmus of Panama, which is little more than eighteen miles across, South America, like Africa, stretches away into the southern hemisphere, bulking broadly beneath the equator, but gradually tapering till it terminates in the bold rocky promontory of Cape Horn. Extending from lat. 12° north to 56° south, and from long. 25° to 82° west, it has an estimated area of 6,820,000 square miles, fully two-thirds of which are situated within the tropics. Like Africa, its triangular outline is little broken by gulfs or bays; but, unlike that continent, it has a gigantic river-system, whose estuaries and channels afford the means of communication with its remotest interior. All its better portions are thus fairly accessible—the only barrier being the lofty ridges of the Andes (practicable only at a few narrow passes), which separate the eastern plains from the

western seaboard. If we except the West Indies, which have been noticed in connection with North America, it has few contiguous islands, and these are comparatively small and of little importance.

343. In physical aspect the continent has been arranged by the authors of the 'New York Atlas' into the following regions:—1. The low-terraced belt of country skirting the shores of the Pacific, from 50 to 150 miles in breadth and 4000 in length, of which the two extremities are fertile, and the middle sandy, arid, and dotted with salinas. 2. The basin of the Orinocco, enclosed by two divergent branches of the Andes, and consisting of extensive plains, called *llanos*, either destitute of wood or merely dotted with trees, but covered during part of the year (the rainy season) with luxuriant herbage. 3. The basin of the Amazon, a vast plain, embracing a surface of more than 2,000,000 square miles, intersected by numerous tributary rivers, possessing a rich soil and humid climate, almost entirely covered with dense forests (*selvas*) and impenetrable jungle-marshes by the river-sides. 4. The great valley of the Plata, occupied chiefly by open plains called *pampas*, in some parts (towards the Andes) barren and shingly, but in general covered with weeds, thistles, and tall grasses, on which feed prodigious herds of wild horses and cattle. 5. The high country of Brazil, eastward of the Paraña and Uruguay; presenting alternate ridges (*sierras*) and valleys, covered with wood towards the Atlantic, but opening into *steppes* in the interior. 6. The sterile region of Patagonia, rising by successive stages from the Atlantic—the soil shingly and strewn with boulders, the grass stunted, and the climate cold and tempestuous. And, lastly, the Andean belt, stretching from south to north, consisting of mountain-ridges covered with snow and volcanic ejections, and of intervening gorges and occasional table-lands, whose elevations confer on their tropical position the climates of temperate regions.

344. Though observations have been made at numerous detached points, the geological structure of the continent is yet imperfectly known. It has been ascertained, however, that the great plains above alluded to are of tertiary or post-tertiary origin; that primary and secondary formations occur in Brazil, Guiana, and Columbia; that a considerable portion of the Pacific seaboard is of recent upheaval; and that within the range of the Andes there are vast exhibitions of crystalline and silurian schists, granites, porphyries, felstones, and other igneous rocks, down to the most recent scoriæ and lavas. The Andes, as well as Brazilian and Columbian sierras, are also rich in metalliferous veins and

precious minerals, and, laying aside the recent discovery of the Californian and Australian gold-fields, no other continent has yielded so long and so plentifully such valuable supplies. Gold, for example, is found in New Grenada, Brazil, Chili, Peru, and Bolivia; silver in Peru, Bolivia, Chili, and La Plata; tin and quicksilver in Peru; copper, lead, antimony, iron, &c., in various districts; coal in Brazil, Chili, and Panama; salt in Grenada and La Plata; nitrates of soda and potash in the salinas of La Plata and Peru; diamonds in Brazil; emeralds and other precious stones in most of the higher regions.

345. With the exception of Tierra del Fuego and Patagonia, which are chilled by the cold currents from the Antarctic Ocean, and the plain of La Plata, which, towards the Atlantic, enjoys a genial and temperate climate, the great bulk of South America is situated within the tropics, and would consequently be subjected to the uniform temperature of that zone, were it not for the widely different elevations of the surface. These altitudes are not, as might be supposed, tantamount to belts of latitude, but are productive of peculiar climatic results, which are thus graphically described by Malte Brun:—The three zones of temperature which originate from the enormous difference of level between the various regions, cannot by any means be compared with the zones which result from a difference of latitude. The agreeable, the salutary vicissitudes of the seasons, are wanting in those regions that are here distinguished by the denominations of frigid, temperate, and torrid. In the frigid zone, it is not the intensity, but the continuance of the cold, the absence of all vivid heat, and the constant humidity of a foggy atmosphere, that arrest the growth of the great vegetable production, and in man perpetuate those diseases that arise from checked perspiration. The hot zone of these places does not experience excessive heat, but it is a continuance of the heat, together with exhalations from a marshy soil, and the miasmata of an immense mass of vegetable putrefaction, added to the effects of an extreme humidity, that produces fevers of a more or less destructive nature, and spreads through the whole vegetable and animal world the agitation of an exuberant but deranged vital principle. The temperate zone, by possessing only a moderate and constant warmth like that of a hothouse, excludes from its limits both the animals and vegetables that delight in the extremes of heat and cold, and produces its own peculiar plants, which can neither grow above its limits, nor descend below them. Its temperature, which does not brace the constitution of its constant inhabitants, acts like spring on the diseases of the hot regions, and like summer in those of the frigid

zones. Accordingly, a mere journey from the summit of the Andes to the level of the sea, or *vice versâ*, proves an important medical agent, which is sufficient to produce the most astonishing changes on the human body; but living constantly in either one or other of these zones must enervate both the body and the mind by its monotonous tranquillity. The summer, the spring, and the winter are seated on three distinct thrones which they never quit, and are constantly surrounded by the attributes of their power.

346. As might be expected from its vast river-plains, tropical situation, and excessive humidity, the continent of South America stands unrivalled in the luxuriance of its vegetable life. In no region is the true tropical forest seen in such perfection, in none is rapidity of growth so remarkable, and in none is there such a development of verdure and foliage. Here is the great headquarters of the palms and melastomas—the former, in numerous genera and species, spreading over an area of nearly 600,000 square miles. "The Amazonian selvas and Brazilian forests present, as we have formerly remarked, the most luxuriant and gorgeous growth of palms and tree-ferns, tangled with rope vines and other parasitical climbers, and studded with the strangest forms of the orchids. Here also flourish the mahogany and other timber trees; the dye-woods of commerce; the siphonia or india-rubber tree; the Brazil-nut, vegetable ivory, and castor-bean; the banana, anana, pine-apple, agave, guava, custard-apple, cassava, pepper-plants, and cactuses of innumerable species, yams, potato, arrow-root, &c.; while the river-creeks are covered with the most gorgeous floaters, among which is the celebrated Victoria Regia of Sir Robert Schomburgk. The higher grounds of Peru and Bolivia are the headquarters of the cinchonas or medicinal barks; the escallonias and calceolarias; and there also flourish the milk-tree, the courbaril or copal-tree, and araucaria. In Paraguay is grown the mattè or Paraguay-tea tree; and in the more tropical portions are cultivated the sugar-cane, coffee, cocoa, chocolate, tapioca, arrow-root, indigo, tobacco, cotton, and a thousand luscious fruits; while in Chili, 'the Italy of South America,' are grown the vine, olive, and European fruits."

347. But while the vegetable element predominates, the animal is subordinated; and, as formerly stated, the fauna of South America is greatly inferior, both in importance and variety, to that of the Old World continents, or even to that of North America. Its tropical regions excel, it is true, in the intensity of their reptilian and insect life, but in all the higher orders there is a remarkable paucity compared with its area and vegetation. Its monkeys, though in myriads, are inferior to the ourang-outangs,

chimpanzees, and gorillas of the Old World ; its bats are numerous, but less so than in the Indian Archipelago ; its chief carnivora are the puma, jaguar, and ocelot, representing the lion, tiger, panther, leopard, &c., of Asia and Africa ; its gnawers (cavies, chinchillas, agoutis, pacas, &c.) are everywhere abundant; its only ruminants are the alpaca, and some small species of deer, there being no natural hollow-horned ruminants like the ox, sheep, goat, or antelope; the edentata (sloths, armadilloes, ant-eaters, &c.) are characteristic of the continent; the only important pachyderm is the tapir; and the chief marsupial the opossum. All its domestic animals—horse, ass, ox, sheep, goat, pig, dog, cat, poultry, &c.—are imports from the Old World ; the only animal it has furnished in return being the alpaca, whose naturalisation in Europe can scarcely yet be said to be established.

348. Ethnologically, the existing condition of South America is extremely curious and complicated. Originally inhabited by the Indian or Red races, some of whom, like the Toltecans or Aztecs of Peru and Bolivia, had made considerable progress in civilisation, it is now partly peopled by Indians, partly by negroes, partly by Europeans (Spanish, Portuguese, British, French, Dutch, &c.), and largely by a mixed race that has arisen from the intercommunion of these varieties. Although there is a large infusion of the Spanish and Portuguese element, the coloured races are still the most numerous, and all the other —English, French, North Americans, &c.—may be regarded as traders and adventurers, rather than settlers in any of the so-called republics. In this way, though civilisation is extending, it has by no means made satisfactory progress. Little has been done, or is doing, in the arts and manufactures; and the industry of the inhabitants is chiefly directed to raising and collecting raw produce—minerals and metals; hides, skins, tallow; woods, dyestuffs, medicinal barks, india-rubber, fibres, gums; sugar, coffee, cocoa, fruits, and farinaceous products—for shipment to Europe. The continent, however, has numerous and noble facilities; and now, since the establishment of more frequent communication with Europe and the United States, the introduction of steam navigation in her rivers, and the adoption of more perfect mechanical appliances, we may naturally look forward to the infusion of better elements of immigration, more permanent settlement, and, as a consequence, better government, and more satisfactory progress.

Oceania.

349. This term has been applied by modern geographers to the numerous islands that are scattered over the bosom of the Pacific and Southern Oceans. Embracing the Indian Archipelago, Australia and adjacent islands, and the truly pelagic groups of the Pacific, its limits may be said to extend from lat. 50° south to 30° north, and from long. 96° east to 150° west in the opposite hemisphere. Its land area has been roughly estimated at 4,200,000 square miles, the greater bulk of which is intertropical, and, consequently, characterised by the climate and products of the torrid zone. It is usual to arrange the whole into several sections (par. 38), but the following—Malaysia, Australasia, and Polynesia—are sufficient for our review, it being borne in mind that the further the groups are removed from the continents on either side the Pacific, the more peculiar do they become in their climatic and vital aspects.

350. Of the first great section, *Malaysia*, which includes the whole of the Indian Archipelago, and lies between lats. 12° 40′ south, and 20° north, it may be remarked that, being strictly intertropical, and separated from the mainland of Asia only by the narrow Strait of Malacca, the Chinese Sea, and Strait of Formosa, it partakes largely of the characteristics of Further India. Consisting of several large islands (Borneo, Sumatra, Java, Celebes, Luzon, &c.) and of minor clusters and chains intersected by narrow straits and intricate channels, its position and configuration are extremely diversified; while its contour is rendered boldly irregular by numerous lines of volcanoes, extinct and active, many of which rise from 6000 to 10,000 and 12,000 feet in height—the culminating altitude being Singalang in Sumatra, 15,000 feet. Hilly and irregular, there are no plains deserving of the name; insular and humid, there are no arid deserts; and, lying directly under the equator, the lowlands abound in jungle and unhealthy swamp, while the uplands are covered by magnificent forest-growth. As might be expected from the proximity, its vegetable and animal productions, with a few exceptions, are specifically the same as those of the tropical mainland; hence the following form the principal exports of the Archipelago :—In the *mineral* kingdom, gold, tin, antimony, bismuth, copper, iron, coal of oolitic age, diamonds, emeralds, and other precious stones: in the *vegetable*, nutmegs, cloves, cinnamon, pepper, ginger, and other spices; coffee, sugar, gums, camphor, cocoa, betel, areca-nuts; indigo, tobacco, cotton, and other fibres; maize, rice, sago, cassava, bread-

fruit; canes, rattans, bamboo, sandal-wood, teak, and other timber: and in the *animal*, ivory, hides, pearls, tortoise-shell, edible bird-nests, whale oil, sharks' fins, ambergris, and similar products.

351. The native inhabitants consist of numerous tribes of the Malay race—Malays, Javanese, Battaks, Dyaks, Bugis, Macassars, Sooloos, &c.; and the foreign settlers of Chinese and Hindoos from Asia, and Spaniards, Portuguese, Dutch, and British, from Europe. There is also an increasing mixed race; but neither these nor any section of the natives have made much progress in the arts or manufactures, while the majority of the independent tribes continue in a state of semi-barbarism. Industrially, the growing of maize, rice, cotton, coffee, &c., the gathering and preparing of raw produce for shipment, fishing, and navigation are the main employments of the most of these rich and fertile islands, whose principal drawback to a better state of things is their sickly and enervating climate.

352. The largest, and in point of promise the most important section of Oceania, is *Australasia*, which embraces Australia, Tasmania, New Zealand, New Guinea, New Britain, New Ireland, New Caledonia, New Hebrides, Solomon's group, and other minor islands, lying between the equator and 47° south lat., and between long. 112° and 180° east. Of New Guinea and the other islands that lie within the tropics, very little is known; Australia partly tropical and partly temperate, Tasmania temperate, and New Zealand also temperate, are the better known and most important portions. Australia, whose extreme dimensions are about 2400 miles from east to west, and 1700 from north to south, may be regarded as a minor continent, enjoying a tropical climate in its northern and a warm-temperate in its southern regions. With the exception of the chain running along the eastern coast (par. 76) there are no known mountains or hill-ranges of any elevation in Australia; the interior of the continent is in general flat, or but slightly undulating, and only occasionally interrupted by rocky eminences; while large tracts of the southern and western seaboards are sandy and shingly. This absence of mountain-ranges and high grounds to attract the rain renders the climate of Australia extremely arid; hence, unless in the New South Wales and Queensland districts, there are no rivers of importance, and none of these navigable; while in the interior what are running channels during the rains are mere pools and brackish creeks during the long-continued seasons of drought. The climate in the settled districts of New South Wales, Queensland, Victoria, and South Australia is described as delightful, but liable to sudden changes, and occasionally to destructive droughts; while in the interior it is hot and arid, and

though the explorers who recently crossed the continent from south to north occasionally met in with wooded and grassy flats, the journey on the whole was through a shingly, scrubby, and waterless country. Tasmania, which occupies an area of about 24,000 square miles, has more hill and dale than Australia, is better watered, and altogether a milder and finer country. New Zealand, which consists of three contiguous islands, about 1100 miles in length, and varying from 5 to 200 miles in breadth, has from its latitude a still more temperate climate, at least in all the low grounds and along the seaboard (for on the higher elevations it is often cold and stormy); is also more hilly and irregular in surface as well as in shore line; and has moreover a copious supply of water.

353. All of these settlements (Australia, Tasmania, and New Zealand) exhibit a variety of geological formations from the old gold-bearing schists down to the most recent gravels, coral-reefs, and volcanic ejections. They are especially rich in the useful minerals and metals—gold, copper, iron, coal, limestone, marble, jade, and building stone; and these supplies must naturally contribute to their future progress, as they have already done to their rapid colonisation. Though devoid of the rich and varied vegetation of tropical regions, they are well supplied with useful timber trees, species of araucaria, eucalyptus, and casuarina (the Norfolk-pine, blue-gums, iron-barks, stringy-barks, swamp-oaks, &c., of the settlers) being numerous and characteristic; while all the cultivated grains, fruits, and vegetables introduced by the European settlers, from the vine, olive, and peach down to the humblest garden produce, can be grown to perfection. With the exception of the dingo or native dog of Australia (the aboriginal existence of which is even problematical), there were no mammals in Australasia at the time of its discovery beyond kangaroos, oppossums, wombats, and other marsupial genera. All the domesticated animals have been introduced by the settlers; to whom, and to the Acclimatisation Society of New South Wales, the region is also indebted for the naturalisation of many of the song-birds, useful insects, and fishes, of the other continents. Of course, in matters of this kind, whether vegetable or animal, the different colonies will be ultimately governed by their geographical position and climate—that which is practicable in New Zealand being impracticable in New South Wales, and what is possible in Southern Australia being impossible in the northern and tropical latitudes of Carpentaria.

354. Ethnologically, the aborigines of the different islands of Australasia are regarded as widely different families of the Malay

race—the dark and savage Papuans of New Guinea and adjacent islands, the feebler and wandering tribes of Australia, and the active, daring, and more intelligent Maories of New Zealand, being the principal offshoots. As yet the Papuans have been little interfered with; the Australian tribes are rapidly disappearing before the advances of the white settlers; and though the Maories have shown more aptitude to imitate, and greater boldness to resist, there can be little doubt that they too must shortly succumb to the influences of a higher civilisation. All the colonies of Australasia belonging to the British, the settlers are principally English, Scotch, and Irish, with a slight infusion, however, of other Europeans, and even Chinese, attracted by the lottery of the gold-fields. As the British element so greatly predominates, with British laws, manners, and appliances, and with, moreover, the most intimate intercommunication with the mother country, the current of Australasian civilisation may be said to run parallel with that of Europe, and can only, after the lapse of generations and the influence of new geographical conditions, be expected to exhibit peculiarities of its own. In the mean time, with their wide pasture-runs, gold-fields, coal-fields, iron-mines, copper-mines, and the facilities of steam communication, the colonies of Australasia are making rapid material progress; and it may be fairly questioned whether, since the establishment of New South Wales in 1788, and of the other provinces since 1828, any settlements under British rule ever exhibited, with less trouble and expense to the mother country, an equal amount of satisfactory and hopeful advancement.

355. *Polynesia* — the usual term employed to designate the numerous islands that stud the bosom of the Pacific within 30 degrees on either side of the equator—embraces the Sandwich, Ladrones, Marquesas, Society, Friendly, Feejee, and other groups, with many other minor clusters and solitary islets that have scarcely a name. Many of these islands, like the Sandwich, Society, and Marquesas, are of volcanic origin, and are still the seats of the most gigantic igneous eruptions; some have old volcanic foundations surmounted and surrounded by upheaved coral-reefs; while others are mere coral-reefs more or less elevated above the level of the ocean. Many of these are extremely irregular in surface, and some, like the Sandwich volcanoes, rise to great altitudes (10,000, 12,000, and 16,000 feet); but, being generally of small dimensions, there is wanting that breadth of surface necessary to the formation of rivers, plains, and other features of geographical diversity. Being of recent geological origin, they afford no mineral or metallic wealth, and their main value lies in their fine climate

and the fertility of their soil. Situated within the tropics, but tempered on all sides by the ocean, by the constant aërial currents which are scarcely interrupted by their dimensions, as well as by their frequent elevation of surface, their climate is said to be delightful, though somewhat enervating and monotonous. Their native productions are the cocoa, bread-fruit, banana, plantain, taro, yam, batata, and other tropical fruits and roots; while the orange, lemon, sugar-cane, cotton, potato, melon, guava, and the like, have been successfully introduced, and flourish luxuriantly in all the larger islands. When first noticed by Europeans there were no quadrupeds on any of the islands save hogs, dogs, and rats (and these may have been the produce of stocks left by previous vessels); but now the horse, ox, goat, sheep, pigs, poultry, and other domestic animals, have been introduced into the larger islands. Most of the islands abound in birds, the shores in sea-fowl, and the waters in fishes, crustacea, turtles, seals, and cetacea.

356. The natives scattered over Polynesia seem offshoots of the Malay race, and though utterly uncivilised, idolatrous, addicted to cannibalism and other barbarous vices, are yet, on the whole (apparently from the unvarying nature of their climate, easy means of subsistence, and isolation), comparatively mild and tractable in their dispositions. This has led to some degree of civilisation in the Sandwich, Society, and Friendly Islands, chiefly through the exertions of British, French, and American missionaries; but as yet to little of that kind of progress which indicates the existence of an inherent and self-sustaining power of improvement. Indeed, it may be questioned how far the limited areas of these islands, the distance of the groups, the want of minerals and metals, the enervating effects of climate, and the easy means of subsistence, will permit of more than a dependent condition of civilisation to the inhabitants of Polynesia.

357. Such are the principal land-areas which form the great themes of Physical Geography—the store-houses of the minerals and metals, the stations of the vegetable and the habitats of the animal kingdom, and thus the varied and inexhaustible fields of human industry and civilisation. Consisting of different geological formations, they possess different minerals and metals; and having different positions, configurations, and contours, they enjoy different climates, and, consequently, produce different vegetable and animal substances. These differences give rise to actions and reactions, physical and vital—for it is only where differences exist that

activities are excited—and in this manner are produced the whole round of phenomena that form the sum and substance of cosmical progress. In the physical world, from the revolution of the planets down to the simplest chemical combination, we see and believe that the whole is the result of law and law-directed forces; and in like manner, in the intellectual world, we may rely, though we cannot always determine, that all the phenomena of civilisation are under the direction of laws as pervading and imperative. To observe and arrange the phenomena of the terraqueous surface, to discover their producing causes, and to give intelligible expression to the law that regulates, is the great object of our science, and it only partially performs its function when, in dealing with the human species, it fails to be guided by the same methods of research. Directed by these methods, and applying them to the whole field of nature, the ordainings of our planet, amid all their myriad ramifications, assume a unity and completeness which it is the great object of science to discover and the highest effort of Philosophy to establish.

GLOSSARY.

A

ABNORMAL (Lat. *ab*, from, and *norma*, a rule).—Without rule or order; irregular; in a condition differing from that produced in the regular course of nature; deviating from the general type or form; not occurring in the usual order, or according to that which is generally considered as the natural law.

ABORIGINES (Lat. *ab*, from; *origo*, beginning or origin).—The first or primitive inhabitants of a country; the original stock (flora or fauna) of any geographical area. — ABORIGINAL: first; primitive; original.

ABSORBENT (Lat. *ab*, and *sorbeo*, I suck in).—Capable of sucking in fluids; in Geography, applied to those soils and subsoils which have the quality of readily imbibing water into their pores or interstices.

ACCLIMATISE (Fr. *acclimater*).—To accustom a plant or animal to a climate not natural to it; to accustom to the temperature and conditions of a new country. Plants and animals may, within certain limits, become acclimatised, and flourish and increase in a new country, though not indigenous to it.

ACOTYLEDONOUS (Gr. *a*, without; *kotyledon*, seed-lobe). — Plants whose embryos have no seed-lobe or seminal leaves are so termed, in contradistinction to *Monocotyledons* and *Dicotyledons*, which see.

ACROGENOUS (Gr. *akros*, the top; *ginomai*, I am formed).—Applied to those cryptogamic plants which increase by growth at the summit, or "growing point," as the tree-ferns. *Acrogens* are therefore separated as a great botanical division from the *Thallogens*, *Exogens*, and *Endogens*.

AERIAL (Gr. *aër*, the air).—Of or belonging to the air or atmosphere; frequenting the air; growing in the air. —SUB-AERIAL; taking place under the air, or on the earth's surface, in contradistinction to *sub-aqueous*, or under the water.

AERIFORM (Gr. *aër*, air; Lat. *forma*, likeness).—Air-like; applied to gaseous fluids, from their resemblance to common air.

AEROLITE (Gr. *aër*, air; *lithos*, stone).—Literally, air-stone; a meteoric stone or mineral mass, which falls through the air, emitting light in its passage, as if red-hot, generally accompanied with a hissing or crackling sound, and occasionally with a report like thunder. Aerolites or meteorites are remarkable for the similarity of their composition, all of them containing *malleable metallic iron*, *nickel*, and *chrome* (ingredients rarely, if ever, found in terrestrial substances), besides silica, magnesia, cobalt, potash, &c. Their origin is yet an unsolved problem: some contending that they are ejected from terrestrial volcanoes; others that they are thrown out from lunar volcanoes; some that they are produced in the atmosphere, being eliminated from vapours exhaled from the earth, and containing volatilised metallic products; and others, again, holding that they are celestial bodies revolving either about the earth or the sun in the manner of planets, and, being involved in the earth's influences, are carried downwards by the force of gravitation.

AFFLUENT (Lat. *ad*, to, and *fluens*, flowing).—Applied to any stream that flows directly into another—the larger or more important being regarded as the *recipient*, and the smaller the *affluent*.—*See* Tributary.

AIGUILLE (Fr.),—A needle; applied in Physical Geography to the sharp serrated peaks of lofty mountains. It is generally the harder crystalline rocks —gneiss, quartz, and the like—which weather into the *aiguille* or needle-top.

ALGÆ (Lat. *alga*, sea-weed).—The general scientific term for those cellular aquatic plants familiarly known as "sea-weeds." Though mostly of marine habitat, many are of fresh-water growth, lacustrine, or fluviatile.

ALLUVIUM, ALLUVIAL (Lat. *ad*, together, and *luere*, to wash).—Matter washed or brought together by the ordinary operations of water is said to be *alluvial*, and the soil or land so formed is spoken of as *alluvium*. The soil of most of our river-plains (dales, vales, holmes, and carses) is of alluvial formation; these low grounds having once been the sites of lakes, estuaries, and shallow arms of the sea.

AMPHIGENS (Gr. *amphi*, all around, and *ginomai*, I am formed).—Plants which increase by the growth or development of their cellular tissue on all sides, as the lichens.

ANADROMOUS (Gr. *ana*, upwards, and *dromos*, a flight or running).—Applied to aquatic animals which, like the salmon and sturgeon, periodically forsake the waters of the ocean and ascend into fresh-water lakes and rivers for the purpose of spawning. Fishes are thus spoken of as *marine*, *fresh-water*, and *anadromous*, the two former never quitting their native elements, and incapable of subsisting in any other, and the latter possessing the power and habit above alluded to.

ANALOGY (Gr. *ana*, along with, and *logos*, reasoning).—That relationship, resemblance, or correspondence which one object bears to another in functional duty or performance.—ANALOGUES, the objects that bear such resemblance or relationship.

ANCHORAGE or ANCHOR-GROUND.—Any portion of a bay, estuary, channel, or arm of the sea, where the bottom is unimpeded by rocks, and the water of a suitable depth for ships riding at anchor.

ANEMOMETER (Gr. *anemos*, the wind; *metron*, a measure).—An instrument (of which there are several kinds) for determining the direction and measuring the velocity and force of the winds.

ANEROID (Gr.)—Literally, without fluid. In the *aneroid barometer* the pressure of the atmosphere is measured by the elevation or depression of the surface of a closed metallic vessel partially exhausted of air. The pressure of the atmosphere being marked at a given time, any alteration is indicated by the movements of the surface of the thin corrugated metal, and communicated to wheels marking the change on a dial furnished with an index. Being easily carried about, the *aneroid* is extremely useful in enabling the traveller and tourist to approximate the relative heights of situations.

ANTARCTIC (Gr. *anti*, opposite, and *arctic*).—Applied to the regions surrounding the south pole, as being opposite to those of the *Arctic* or north pole, which see. Thus, we speak of "antarctic regions," "antarctic circle" (66½° south of the equator), and of situations "within the antarctic circle."

ANTHRACITE (Gr. *anthrax*, coal).—A species of coal almost wholly deprived of its bitumen, and which, therefore, burns without smoke or flame. It may be regarded as a natural coke or charcoal, formed from ordinary bituminous coal by subterranean or chemical heat. It occurs in most coal-fields, but largely, and on a most available scale, in the United States of America.

ANTICLINAL (Gr. *anti*, opposite, and *klino*, I bend).—Bending or sloping in opposite directions from a common ridge or axis, like the roof of a house. Such a ridge or axis is called, in geological language, an "anticline" or "saddle-back."

ANTIPODES (Gr. *anti*, opposite; *pous*, *podos*, foot).—Applied to those who dwell on opposite sides of the globe, as having their feet diametrically opposed to each other. Those in New Zealand, for example (or rather Antipodes Island, near New Zealand), are the antipodes of those in Great Britain.

ANTISEPTIC (Gr. *anti*, opposed to; *sepo*, I putrefy).—Substances which, like common salt and tannin, prevent putrefaction in animal and vegetable matter, are said to be *antiseptics*, or to possess *antiseptic properties*.

APHELION (Gr. *apo*, from; *helios*, the sun).—The point in a planet's orbit at which it is farthest from the sun; its *perihelion* being the point at which it is nearest.

APOGEE (Gr. *apo*, from; *ge*, the earth).—That point of the moon's orbit in which she is farthest from the earth; her *perigee* being the point in which she is nearest the earth.

AQUATIC (Lat. *aqua*, water).—Relating to the water; having its habitat or usual position in water. Applied to plants which, like the water-lily, grow in water, and to animals which, like the duck and diver, live in or frequent the waters.

AQUEOUS (Lat. *aqua*, water).—Watery; pertaining to, or formed by, water. We thus speak of aqueous vapours, aqueous solutions, aqueous or sedimentary strata, and the like.—SUB-AQUEOUS: occurring under the water; in contradistinction to *sub-aërial*, or under the open air.

ARCHIPELAGO.—A term originally applied to the numerous islands that stud the Ægean Sea — the *Grecian Archipelago;* but now used to denote any similar cluster of islands—*e.g.*, the Indian Archipelago, or East India Islands.

ARCTIC (Gr. *arktos*, a bear).—Relating to the north pole or polar regions; in reference to the constellations of the Great and Little Bears which occur in the northern quarter of the heavens, and point, as it were, to the north pole.—*Arctic Regions*, the high latitudes surrounding the north pole: *Arctic Circle*, an imaginary line extending round the north pole 66½° from the equator and parallel to it; hence certain parts are said "to lie within the arctic circle."

ARCTIC CURRENT.—A well-known ocean current which originates in the polar regions of the north and flows southwards towards the equator. The main current seems to originate to the north of Spitzbergen, takes a westerly direction, and thence runs southward along the eastern shores of Greenland, till it meets with a minor branch flowing from Davis Straits. The two then unite into one great current, which follows the Labrador coast, runs to the east of Newfoundland, and evidently loses itself in the "Gulf Stream;" or rather, perhaps, from its greater density, passes in part under the Gulf Stream in latitude 45°—47°, and holds on towards the equator.

ARGENTIFEROUS (Lat. *argentum*, silver; *fero*, I yield).—Applied to veins, rocks, and, other matrices containing the ores of silver, or silver in the native or metallic state.

ARGILLACEOUS (Lat. *argilla*, clay).—Applied to all soils, rocks, or substances composed of clay, or having a notable proportion of clay in their composition.

ARM.—Any deep and comparatively narrow branch of the sea running inland, in contradistinction to gulfs and firths.

ARTESIAN WELLS.—Wells sunk by boring perpendicularly through the solid strata, and in which the subterranean waters rise to the surface, or nearly so—a method long known and practised in the province of Artois (the ancient Artesium) in France. Artesian wells are generally situated in plains, or in basin-shaped valleys, towards which the strata dip on one or more sides, and their principle depends upon the hydrostatic pressure of the water percolating the inclined strata, and forcing its way upward by the artificial orifice to the highest level of the water-bearing stratum. The greater the depth the higher the temperature of the water; and the lower the surface of the well compared with the outcrop of the water-yielding stratum, the higher will the jet of water rise above the orifice of the bore.

ASTEROIDS (Gr. *aster*, star; *eidos*, likeness).—A term applied by Herschel to the minor planets or *planetoids*—Ceres, Pallas, Juno, Vesta, &c.—of which there are now upwards of seventy known to astronomers.

ATMOMETER (Gr. *atmos*, vapour, and *metron*, measure).—An instrument invented by Sir John Leslie for measuring the amount of evaporation from any liquid or moist surface in a given time.

ATMOSPHERE (Gr. *atmos*, vapour; *sphaira*, sphere).—The gaseous envelope or volume of air which surrounds the earth on every side, and which is either directly or indirectly the cause of numerous geological and geographical operations, as well as the immediate medium of all climatic diversity—being the great laboratory in which all meteorological and electrical phenomena are elaborated, as winds, clouds, rains, snow, hail, and thunderstorms. As an air, it is composed of 79 parts nitrogen and 21 oxygen, with variable traces of carbonic acid and other impurities. Calculating from its decreasing density, as well as from its diminished power of refracting light, as we ascend from the earth, the height of the atmosphere has been estimated at 45 or 50 miles; and the pressure of the whole volume on every square inch of the earth's surface (at the ordinary sea-level) at 14.6 lb. avoirdupois.

ATOLL.—The name given to a coral island of an annular form—that is, consisting of a circular belt or strip of coral-reef more or less continuous, with an enclosed lagoon.

AURIFEROUS (Lat. *aurum*, gold; *fero*, I yield).—Yielding or containing gold; applied to veins, rocks, and rock-substances containing the precious metal, as "auriferous veins," "auriferous gravels," and the like.

AURORA BOREALIS (Lat.)—Literally the "Aurora of the North;" known also as the *Northern Lights*, *Polar Lights*, *Streamers*, &c. A luminous meteor, generally appearing in the northern heavens, and so called from its resemblance to the *aurora* or morning twilight. It is usually referred to electrical agency in the upper regions of the atmosphere. Changing from the purest and softest white to all the colours of the rainbow, and flickering and flitting from the horizon to the zenith with inconceivable rapidity, the aurora borealis is one of the most attractive of celestial phenomena.

AUTUMN (Lat.)—The third quarter of the year which commences when the sun enters *Libra*, that is, about the 21st or 22d of September, when the days and nights are equal; hence the term *Autumnal Equinox* or *Autumnal Point*, referring to the descending point of the ecliptic.

AVALANCHE (Fr. *avalange*, *lavange*, *lavanche*).—An accumulation of snow, or of snow and ice, which descends from precipitous mountains like the Alps into the valleys below. Avalanches originate in the higher regions of mountains, and begin to descend when the gravity of their mass becomes too great for the slope on which it rests, or when fresh weather destroys its adhesion to the surface. They are usually distinguished as Drift, Rolling, Sliding, and Glacial;—*Drift* are those caused by the action of the wind on the snow while loose and powdery; *Rolling*, when a detached piece of snow rolls down the steep, licks up the snow over which it passes, and thus acquires bulk and impetus as it descends; *Sliding*, when the mass loses its adhesion to the surface, and descends, carrying everything before it unable to resist its pressure; and *Glacial*, when masses of frozen snow and ice are loosened by the heat of summer and precipitated into the plains below.

AXIS (Lat. a pole or axletree).—A word used largely and variously in natural science; applied to the line about which objects are symmetrical, about which they are bent, around which they turn, or to which they have some common relation; hence "vertebral axis;" "axis of elevation;" "axis of rotation;" "synclinal axis," &c.

B

BAROMETER (Gr. *baros*, weight; *metron*, measure).—A well-known instrument for measuring the weight or pressure of the atmosphere by balancing a column of air against a column of mercury; and by this test determining variations in the state of the air, foretelling changes in the weather, as dependent on the conditions of the air, and measuring heights and depths as indicated by the proportional pressure of the air.

BARRIER REEF.—The name given to those coral-reefs that run parallel (*barrier-like*) to the shores of islands and continents, but separated therefrom by a lagoon-channel more or less extensive. The barrier-reefs of Australia and of New Caledonia, owing to their enormous dimensions, have long excited the attention of voyagers.

BASIN.—Applied, in Geography, to the whole extent of valley-shaped or basin-shaped country drained by any river and its tributaries, as the "basin of the Thames," the "basin of the Forth," &c.

BATHYMETRICAL (Gr. *bathys*, deep, and *metron*, measure).—Applied to the distribution of plants and animals along the sea-bottom, according to the depth of the zone (measuring from the shore) which they inhabit.

BAY.—Any bending of the ocean into the land, less sudden and contracted than a *creek* or *harbour*, and communicating more openly with the main ocean than a *sea* or *gulf*; "Bay of Biscay," "Bay of Bengal."

BEACH.—The shore of the sea; the strand—strictly speaking, that space along the margin of a tidal sea over which the tide alternately flows and ebbs.

BIOLOGY (Gr. *bios*, life, and *logos*, doctrine).—The science of life, whether vegetable or animal, embracing botany and zoology in their widest acceptation. — BIOLOGICAL, relating to the science of life; life in all its multifarious manifestations and developments.

BISE.—A cold and cutting north-east wind which descends from the snow-covered Alps in spring and early summer; often ravaging the south of France.

BLANCHING (Fr. *blanche*, white).—The process of whitening the leaves and stems of plants by excluding the light, and thus preventing the development of their natural properties. —BLANCHED, whitened.

BLUFFS.—A term said to be of American origin, and used to designate high banks presenting a precipitous front to the sea or a river.

BOG (Celtic, *soft*).—The common designation for any wet, spongy morass, consisting chiefly of decayed vegetable matter.—BOG-EARTH, soils composed in the main of decomposed vegetable matter, with a considerable proportion of light siliceous sand.

BOILING POINT.—The precise temperature at which a liquid begins to *boil* or bubble up under the influence of heat. The boiling points of liquids are constant under precisely the same circumstances. The causes which induce variation are increased or diminished atmospheric pressure, the greater or less depth of the liquid, and the nature of the vessel in which it is contained. Thus, the boiling point of water under ordinary circumstances, at the level of the sea, is 212° Fahr.; but it will boil and bubble up at a much lower temperature on the top of a high mountain, in consequence of diminished pressure; it will also boil sooner and more quietly in a rough-surfaced vessel than in a smooth and polished one; and also more quickly in a shallow vessel, in consequence of the less resistance by the superincumbent water to the escape of steam. The boiling point is also raised considerably by saline admixture, so that pure water, which boils at 212°, requires 285° when fully saturated with salt. *In vacuo*, all liquids boil at a temperature 124° lower than in the open air, at the ordinary pressure of the atmosphere.

BORE.—A violent rush of tidal water; the advancing edge or front of the tidal wave as it ascends a river or estuary; *e.g.*, the bore of the Hooghly, the Garonne, the Severn, the Tsientang, &c. The bore of the Tsientang is said to advance up that river at Hangchau like a wall of water, thirty feet in height, and at the rate of twenty-five miles an hour, sweeping everything before it.

BOREAL (Lat. *Boreas*, the north wind).—Of or belonging to the north; *e.g.*, Boreal Regions, Boreal Fauna, &c.

BOTTLE-TRACK.—The name given to the course pursued by bottles which are thrown overboard with a note enclosed of the longitude and latitude where and the date when they are dropped in the ocean. By this means the set-in and velocity of currents are rudely indicated.

BOULDERS (Sax.)—Any rounded or water-worn blocks of stone, which would not, from their size, be regarded as pebbles or gravel, are termed *boulders*. The name, however, is usually restricted to the large water-worn and smoothed blocks ("erratic blocks") found imbedded in the clays and gravel of the Drift formation, which covers the northern hemisphere, in both worlds, down to the 40th or 42d parallel of latitude.

BOURRANS.—The name given to the fierce snow-storms that blow from the north-east over the steppes of Russia, and which often rage for twenty-four hours at a time.

BREEZE.—The general term for a wind of some briskness, but of limited extent and duration; less violent than a *gale*.

C

CAINOZOIC or CAENOZOIC (Gr. *kainos*, recent; *zoe*, life).—Applied to the upper stratified systems, as containing recent forms of life, in contradistinction to the *Mesozoic* (holding intermediate) and the *Palæozoic* (holding ancient and extinct forms). As a palæontological subdivision, the Cainozoic embraces the tertiary and post-tertiary formations.

CALCAREOUS (Lat. *calx*, *calcis*, lime).—Composed of or containing a considerable proportion of lime; *e.g.*, *calcareous soils*, *calcareous sandstones*, &c.

CALCARIFEROUS.—Literally, lime-yielding. A term occasionally applied to springs charged with carbonate of lime, and which on issuing into the air deposit incrustations of calcareous tufa. The "petrifying springs" of ordinary language.

CALDÉRA.—A Spanish term for the deep caldron-like cavities that occur on the summits of extinct volcanic mountains and islands, and evidently the extinguished craters of ancient volcanoes.

CAPILLARY (Lat. *capillus*, a hair).—Hair-like; applied to filaments, tubes, and the like, of very fine or hair-like dimensions. A tube less than the twentieth of an inch in diameter is capable of sustaining or attracting any liquid considerably above the level at which it is immersed; and this *capillary attraction*, as it is termed, is a phenomenon which occurs less or more in all porous bodies (soils, sandstones, &c.)—the minute interstices acting as capillary tubes, and "drawing" or "attracting" any liquid considerably above the level of its mass.

CARBONIFEROUS (Lat. *carbo*, coal; *fero*, I yield).—Coal-bearing, coal-yielding. The term is usually applied to that system of strata from which our main supplies of coal are obtained, or to the respective groups or members of that system; *e.g.*, "carboniferous system," "carboniferous limestone," &c.

CARDINAL (Lat. *cardo*, a hinge).—A term implying importance, and suggestive of the hinge or point on which a thing turns or depends. Thus the *cardinal points* of the compass are the North, South, East, and West; the *cardinal signs* of the zodiac, Aries, Cancer, Libra, and Capricorn.

CARNIVORA (Lat. *caro*, *carnis*, flesh; *voro*, I devour).—One of Cuvier's orders of the mammalia, embracing the lion, tiger, hyena, and others that subsist solely on flesh.—CARNIVOROUS, living on flesh, in contradistinction to *Herbivorous*, *Gramnivorous*, &c.

CATACLYSM (Gr.)—A sudden flood, deluge, or inundation. Generally applied to some abnormal or unusual effect of moving water.—CATACLYSMAL, belonging to, or produced by, the violent force of water.

CHALYBEATE (Gr. *chalybs*, iron or steel).—Applied to springs and waters impregnated with iron, or holding iron in solution.

CLIMATE (Gr. *klima*, an inclination).—Originally applied (as explained in the text), in a technical or astronomical sense, to the various belts of the earth as influenced by the heat of the sun; but now applied to the general *weather-conditions* of any district, as these may be mild or rigorous, genial or ungenial, salubrious or obnoxious. In treating of countries, geographers speak of *insular* and *continental* climates; the former, from its proximity to the ocean, being comparatively mild in winter and cool in summer, and the latter cold in winter, but excessively hot in summer.

CORAL-REEF.—The term applied to any connected mass of coral structures, whether trending away in long partially-submerged ledges, encircling islands like breakwater-barriers, or rising as low ring-shaped islets above the waters of the ocean. Such masses are found studding the Pacific on both sides of the equator to the thirtieth degree of latitude; abounding in the southern part of the Indian Ocean; trending for hundreds of miles along the north-east coast of Australia; and occurring less or more plentifully, in patches, in the Persian, Arabian, Red, and Mediterranean Seas. In the Pacific, where volcanic agency is actively upheaving and submerging, coral-reefs are found forming low circular islands, enclosing lagoons (*atolls* or *lagoon islands*); surrounding islands of igneous and other origin (*fringing* or *shore reefs*); crowning others already upheaved (*coral-ledges*); or stretching along-shore in surf-beaten ridges (*the true barrier* or *encircling reef*) of many leagues in length, and from 20 to more than 200 feet in thickness.

COSMOS (Gr. *kosmos*).—Literally, order; natural order, like that prevailing in the universe. The whole framework of the material universe; the *world*, from the orderly arrangement and symmetry of its component parts.—COSMICAL, relating to the world or universe.—COSMOLOGY, the science which treats of the several parts of the world, their laws and relations.

COULÉES (Fr. *couler*, to flow, as melted metal).—Applied to the *streams* and spurs of lava which diversify the sides and slopes of volcanic mountains.

CRAG AND TAIL.—Applied to a form of hills common in Britain, where a bold precipitous front (the crag) is exposed to the west or north-west, and sloping declivity (the tail) towards the east. In general geographical terms, the *slope* and *counter-slope* of these hills. The phenomenon of crag and tail is evidently the result of the currents of the Drift epoch, which, in our latitudes, swept from north-west to north-east, laying bare the opposing heights, but leaving untouched the sheltered slopes and terraces.

CRATER (Gr. *krater*, a cup or bowl).—The mouth or orifice of a volcano: so called from its cup or bowl shape. Craters may be central or lateral in the mountain in which they occur; there may be one principal and several subsidiary ones; and they may shift their places and become absorbed by subsidence, or be obliterated by eruptions from more active orifices.

CRATERIFORM.—Applied to hills whose summits present bowl-shaped and other circular depressions that seem to have been the craters of once active volcanoes. We thus speak of the "crateriform hills of Auvergne"—hills which were undoubtedly in a state of igneous activity during the tertiary period.

CUPRIFEROUS (Lat. *cuprum*, copper, and *fero*, I yield).—Applied to veins, rocks, and other matrices containing the ores of copper, or copper in the native or metallic state.

CYCLE (Gr. *kuklos*, a circle).—A definite period of time, marked by the recurrence of the same natural phenomena.

CYCLONE (Gr. *kuklos*, a circle).—A term applied by navigators to those rotatory hurricanes which occur most frequently between the equator and the tropics, and near the equatorial limit of the trade-winds. They sweep round and round with a progressive motion, their course describing a curve, and their violence being greater the narrower the limit of their whirl. In both hemispheres the rotation of a cyclone is *contrary* to that of the sun; those in the northern hemisphere moving counter, so to speak, to the motion of a watch-hand, those in the southern following that motion.

D

Debacle (Fr. *debacler*, to unbar). — A term originally signifying the breaking up of the ice on a river—a freshet; but now applied to any sudden flood or rush of water which breaks down opposing barriers, and hurls forward and disperses blocks of stone, gravel, and other debris.

Debris (Fr., wreck or waste.)—A convenient term, adopted from the French, for any accumulation of loose material arising from the waste of rocks: also for drifted accumulations of vegetable or animal matter.

Degradation (Lat. *de*, down, and *gradus*, step). — Removing or wasting down step by step. The degradation of hills and cliffs is caused by atmospheric and aqueous agency; hence water is said to exert a *degrading* in fluence on the earth's crust; waves and tidal currents a *degrading* action on certain sea-shores.

Delta.—The alluvial land formed at the mouth of a river such as that of the Nile, which received this name from the resemblance of the space enclosed by the two main branches of the river to the Greek letter Δ, *Delta*. The deltas of many large rivers, such as the Mississippi, Niger, Ganges, &c., present the inquirer with some of the most remarkable and instructive of geographical and geological phenomena.

Deposit (Lat. *de*, down; *positus*, placed). —Applied to matter that has settled down from suspension in water. Deposits are either distinguished by their composition, as "mud-deposits," "sand-deposits," &c.; by the positions in which they occur; or by the agencies concerned in their formation, as fluviatile, lacustrine, estuarine, marine, &c.

Detritus (Lat. *de*, down; *tritus*, rubbed or worn).—An appropriate term for all accumulations arising from the waste or disintegration of exposed rock-surfaces, sea-cliffs, mountain-cliffs, river-banks, and the like. *Detrital* matter may thus consist of mud, sand, gravel, rubbly fragments, or of any admixture of these.

Dicotyledonous (Gr. *dis*, double; *kotyledon*, seed-lobe).—A grand division of the vegetable kingdom, comprising all those plants whose seeds are composed of two lobes or seed-leaves. They are exogens, or increase by external layers of growth, and the venation of their leaves is reticulated or net-like, and not in parallel order, as in monocotyledonous endogens.

Dip.—The inclination or angle at which strata slope or dip downwards into the earth. This angle is measured, of course, from the plane of the horizon or level, and is easily ascertained by the common spirit-level and plummet. Some rocks dip at a low angle and are flat; others incline at a very high angle, and are almost on edge.

Doab.—The name given in India to the tongue of land that lies between the confluence of two or more rivers, as the *doabs* of the Punjaub, or plains that lie between the rivers of that region.

Doldrums.—A sailor's term for the tropical zones of calms and variables—belts in which they are often detained for weeks by baffling calms, storms, and rains.

Downs (Brit. *dune*, a hillock).—Applied in the south of England to the rounded, dry, and unwooded chalk hills of Kent, Surrey, Sussex, and adjacent counties. These "downs" are described "as covered with a sweet, short herbage, forming excellent sheep-pasture, generally bare of trees, and singularly dry even in the valleys that wind for miles between them."

Drift.—Literally, "that which is driven;" as *sand-drift*, sand driven and accumulated by the wind; *drift-wood*, wood carried down by rivers and driven by tides and currents to distant shores. Such drift-wood is often useful in indicating to geographers the course and direction of oceanic currents.

Drift-Currents.—The name given to oceanic currents which mainly depend on the winds. The monsoons which prevail in the Indian Ocean give rise to drift-currents, which set alternately in one direction and then in another, according to the season of these winds.

Drosometer (Gr. *dros*, dew; *metron*, measure).—Literally "dew-measurer;" any apparatus or instrument for determining the amount of dew deposited during a single night. "The most simple process," says Professor Kaemtz, "consists in exposing to the open air bodies whose exact weight is known, and then weighing them afresh after they are covered with dew. According to Dr Wells, locks of wool, weighing five decigrammes, are to be preferred, which are to be divided into sperical masses, of the diameter of about five centimetres."

Dune (Brit. a hill).—Usually applied to hillocks of blown sand. *Sand-dunes*, sand-drift like that which, in so many places, skirts the low shores of our own island.

E

Earth's Crust.—That external rind or shell of our planet which is accessible to human investigation; in contradistinction to the internal mass, of which we can know nothing by direct observation.

Earthquake.—The familiar as well as technical term for any sudden shaking or tremor of the earth's crust produced by subterranean agency. With the causes that produce, and the conditions that accompany earthquakes, we are but slenderly acquainted; but we know that their results are fractures, fissures, and chasms in the earth's crust; upheavals and depressions; elevations of the sea-bed into dry land, and the submergence of dry land beneath the waters of the ocean.

Eddy (Sax. *ed*, water, and *ea*, backwards).—Any rotatory motion of water caused by the meeting of opposing currents. Eddies generally occur in estuaries where the tide meets the current of the river; and in seas where currents from different quarters meet, or where tidal currents are thrown back on themselves by opposing obstacles.

Embouchure (Fr.)—The mouth of a river, or that part where it enters the sea.

Endogens (Gr. *endon*, within; *ginomai*, I am formed).—That division of the vegetable kingdom whose growth takes place from within, and not by external concentric layers as in the *Exogens*.

Equator (Lat. *æquus*, equal).—The great circle on the earth's surface, every point of which is equally distant from the poles; such a circle cuts the globe into two equal parts or halves—in other words, into *hemispheres*, viz., the Northern and Southern. When the sun is in the line of the equator, day and night are of equal duration, hence it is also termed the *equinoctial line* (*nox*, the night).—Equatorial, belonging to, or in the region of, the equator.

Erosion (Lat. *erosus*, gnawed or worn away).—The act of gradually wearing away; the state of being gradually worn away, *e.g.*, "Valleys of erosion," or those valleys which have been gradually cut out of the solid strata by the long-continued action of the river or rivers that flow through them.

Erratic Blocks. — A term frequently applied to those large water-worn and ice-borne blocks of stone (*boulders*) which are scattered so generally over the higher and middle latitudes of the northern hemisphere.

Escarpment (Fr. *escarper*, to cut steep). —The abrupt face or cliff of a ridge or hill-range.

Estuary (Lat. *æstus—æstuo*, I boil—the tide; so called from the troubled boiling-up of the water-line, which marks its approach in river-mouths).—Estuaries are, properly speaking, tidal river-mouths, like those of the Thames, Severn, Solway, &c., whose fauna and flora are mixed fresh-water and marine, or composed of such species as are peculiar to brackish waters.

Etesian Wind (Gr. *etesios*, annual).—A northerly, or rather north-easterly wind that prevails very much in early summer all over Europe.

Ethnography (Gr. *ethnos*, a race; *graphe*, a description).—An account or description of the origin, dispersion, connection, and characteristics of the various races of mankind.

Evaporation (Lat. *evaporo*, I send off in vapour). —The act of converting into vapour such liquids as water, either by natural or by artificial means, the former being termed "*spontaneous evaporation*." Heat is the grand evaporating agent in nature, and its effects are greatly facilitated by the removal of the vapour as soon as it is formed either by currents of wind, by absorption, or by other analogous means.

Exogens (Gr. *exo*, without; *ginomai*, I am formed).—That great division of the vegetable kingdom whose growth takes place by external concentric layers, and not from within as in the *Endogens*.

Exotic (Gr. *exon*, from without).—Applied to plants and animals, but chiefly to the former, that have been introduced into a country from other regions—that is, from without. Used in contradistinction to *indigenous*, or naturally belonging to a region, which see.

F

Facies (Lat.)—A convenient term employed to express any common resemblance or aspect among the rocks, plants, animals, or fossils of any area or epoch. Thus we speak of the "facies of the Carboniferous flora," as distinct from the floras of other epochs; and of the "facies of the Australian fauna" as distinguished from the animals of other regions by their common marsupial characteristics.

FAMILY.—In Natural History classifications this term denotes the group next in value and comprehensiveness above the *genus*. As species constitute a genus, so genera constitute a family.

FATA MORGANA.—The phenomenon of the *mirage* at sea. It arises from two currents of air of different density or temperature coming suddenly in contact; and as at sea the upper is generally the warmer and the lower the colder, the former becomes condensed at the place of contact, and forms, as it were, a mirror for the objects which are in the lower current, so that their images are inversely reflected. As the surface of separation is not level throughout, various refractions and distortions result, which often impart to the whole a singular and fantastic appearance. On land, where the warmer current of air is on the surface of the ground, the aërial mirror is formed beneath the eye of the observer, by which the same phenomenon is produced that results from the reflection of objects on the surface of the water. The name is said to be of Breton origin—*mor*, sea, and *gana*, fine lady—the fairy mermaid of our popular legends.—*See* Mirage.

FAUNA (Lat. rural deities).—A convenient term for the animals of any given epoch or area; *e. g.*, the "fauna of South America," the "fauna of the Permian era." As the animals of an area or epoch constitute its FAUNA, so the plants constitute its FLORA.

FERRIFEROUS (Lat. *ferrum*, iron; *fero*, I yield).—Applied to veins, rocks, and other matrices that yield or contain iron.

FERRUGINOUS (Lat. *ferrum*, iron; *ginomai*, I become).—Impregnated or coated with oxide of iron; rusty-looking.

FLORA (Lat. the goddess of flowers).—A convenient term for the vegetation of any given epoch or area—as "the flora of the coal-measures"—"the flora of South America." As the plants of a country or epoch constitute its FLORA, so the animals constitute its FAUNA.

FLUVIATILE (Lat. *fluvius*, a running water).—Belonging to a river; produced by river action; growing or living in fresh-water rivers.

FOSSIL (Lat. *fossilis*, dug up).—Literally, anything dug out of the earth; but now restricted by geologists to "organic remains," or the remains of plants and animals imbedded in the earth's crust, and more or less altered in structure and composition by mechanical and chemical agencies. When these remains are only partially petrified, and occur in superficial or recent deposits, the term *sub-fossil* is employed.

FOSSILIFEROUS (Lat. *fossilis*, and *fero*, I bear).—Applied to rocks and rock-systems containing organic remains, in contradistinction to *non-fossiliferous*, or those which contain no such relics.

FRESHET.—A river flood or inundation occasioned by the sudden melting of the ice and snow in spring; the predominance of fresh water in tidal estuaries during periodical rain-falls and land-floods.

FRINGING-REEFS. — A class of coral-reefs, known also as "shore-reefs," from their fringing or encircling islands at a moderate distance from shore. "They differ from barrier reefs," says Darwin, "in not lying so far from shore, and in not having within a broad channel of deep water." The reefs which fringe the island of Mauritius form a good example of the class.—*See* Coral Reef.

FRITH (Lat. *fretum*).—An arm of the sea, as the Frith of Forth, the Frith of Tay, &c. Originally applied to any strait narrow passage, or inlet.

FROST (Sax.)—In Meteorology, the freezing, or conversion into ice, of water and watery vapours by the influence of cold. In ordinary circumstances water passes into ice when the temperature of the air falls to 32° of Fahrenheit; but as the cold increases the frost becomes more intense, and substances (such as oils, mercury, &c.) which remained liquid at 32°, gradually lose their caloric and pass into the solid state. As a geological agent, frost exerts a purely mechanical influence, but this influence is of prime importance in disintegrating rocks and soils, moulding the outline of mountains, and assisting in the dispersion of boulders and other debris, not only from higher to lower levels, but from the land over the bottom of the ocean. The *avalanche*, *glacier*, and *iceberg*, among the most notable of geographical phenomena, are the children of the frost, cradled on the snowy summits of lofty mountains, or in the icy seas of the polar regions.

FUMEROLE (Ital. *fumare*, to smoke).—An opening or orifice in a volcanic district from which eruptions of smoke and other gaseous fumes are emitted.

G

Garua.—The local term for dense sea-fogs that occur periodically along the Pacific coast of South America. During the Garua, it is said, the atmosphere loses its transparency, and the sun is obscured for months together. The vapours of the garua of Lima are so thick that the sun, seen through them with the naked eye, assumes the appearance of the moon's disc. They commence in the morning, and extend over the plains in the form of refreshing fogs, which disappear soon after mid-day, and are followed by heavy dews, which are precipitated during the night.

Genus (Lat. kind or kindred).—In Natural History the word *genus* is generally used to embrace such members of a family or larger group as possess some common properties, more marked in them than in the other members of the family. Thus the Canidæ or Dog-family embraces the dog, wolf, jackal, fox, &c.; but the dog, wolf, and jackal are regarded as one genus, *canis*, while the foxes are separated into another genus, *vulpes*, the points of agreement between the dog and wolf being more numerous and intimate than between the dog and fox.

Geology (Gr. *ge*, the earth, and *logos*, doctrine).—Embraces all that can be known of the constitution and history of our planet. Its object is to examine the various rock-materials of which our planet is composed, to describe their appearance and relative positions, to investigate their nature and mode of formation, and generally to discover the laws which seem to regulate their arrangement. In this respect it differs from *Geography*, which restricts itself more especially to the external or superficial aspects of the globe, and the life that adorns it.

Geyser. — Literally "rager;" an Icelandic term for the intermittent boiling springs or spouting fountains which occur in connection with the volcanic phenomena of that island. The term has reference to the violent discharges of steam and water which take place at stated intervals, the jets being thrown with explosive force to a great height in the air.

Ghauts.—A term applied originally to the narrow and difficult passes in the mountains of Southern India, but has been gradually extended to the mountains themselves — viz., the Eastern and Western Ghauts, which consist of two great chains, stretching along the east and west coasts of the Deccan.

Glacier (Lat. *glacies*, ice).—Applied to those accumulations of ice, or of snow and ice, which collect in the valleys and ravines of snowy mountains like the Alps, and which move downward (partly by their own gravity, and partly by the expansion of the water that falls into their crevices and fissures), with a peculiar creeping motion, smoothing the rocks over which they pass, and leaving mounds of debris (*moraines*), lateral and terminal, as they melt away.

Glacier-Table.—The name given in Alpine regions to large table-like blocks of stone lying on the surface of glaciers, and more or less elevated on pedestals of ice—these pedestals being protected from the sun's rays by the superincumbent stone blocks, while the surrounding ice has been melted down to a lower level.

H

Habitat.—The region occupied by any particular animal is called its *habitat*, and that of any particular plant its *station*—each being the locality which presents the conditions most favourable to its growth and development.

Hail.—Frozen rain; rain-drops that have been suddenly frozen in their downward course by passing through a stratum of air below the temperature of 32°. Hail pellets are of various forms—round, angular, or flat—and often of considerable size.

Headland.—Any prominent projection of the land into the sea; usually applied to a *cape*, *ness*, or *promontory* of some boldness and elevation.

Herbaceous. — Applied in Botany to stems that die down annually, in contradistinction to *ligneous* or woody, persistent stems.

Herbivorous.—(Lat. *herba*, herb, and *voro*, I devour).—Herb-eating; subsisting on vegetable food; in contradistinction to *carnivorous*.

Hervidero (Span. *hervir*, to boil).—The name given in Central America to the mud-volcanoes which occur in that and the contiguous districts of Mexico. The *hervideros* consist of mounds more or less conical, with a crater at top, in which a clayey, fetid mud, of various colours and consistency, is kept in continual ebullition, and which is occasionally thrown up in pasty flakes that fall around, and form the conical mounds in question.

HOMOIOZOIC (Gr. *homoios*, the same, and *zoe*, life).—Zones or belts of the ocean which, being under nearly the same circumstances as to climate, and consequently peopled in their different parts either by the same or representative species of animals, are said to be *homoiozoic*, or marked by the same life.

HORNITOS or HORNOS.—Literally *ovens;* a Spanish term for the low oven-shaped mounds or hillocks so frequent in the volcanic districts of South America, and from whose sides and summits columns of hot smoke and other vapours are usually emitted. They are only a few feet in height (five to ten), and, according to Humboldt, are not *eruptive cones*, but mere intumescences on the fields and sides of the larger volcanoes.

HUMMOCK (Sax., a knoll or mound).—Applied by sailors to blocks and masses of ice which have been frozen together so as to produce a rugged and uneven surface of the general ice-field.

HYGROMETER (Gr. *hygros*, moist; *metron*, measure).—An instrument for determining the humidity of the atmosphere. There are various kinds of hygrometers—some depending upon the principle of absorption of moisture, others upon the contraction of absorptive materials, and some, again, upon the principle of condensation upon cold polished surfaces.

I

ICEBERG (Ger. *eis*, ice, and *berg*, mountain).—The name given to the mountainous masses of ice often found floating in the polar seas. Sometimes they are formed by the accumulation of ice and snow; at other times they seem to have been originally glaciers launched from precipitous coasts into the ocean, and there further augmented by numbers of them freezing *en masse*. Icebergs have been seen in the Arctic and Antarctic Oceans several miles in circumference, rising from 40 to 200 feet above the water, and loaded with blocks of rock and masses of shingle. Some idea of their size may be formed from the fact that little more than an eighth of their bulk rises above the surface. As they are floated by the polar currents to warmer latitudes they melt away, dropping their burdens of boulder and rock-debris on the bottom of the ocean.

ICE-FLOE (Dan. ice-island).—Applied by voyagers to the smaller masses of ice that encumber the polar seas.

INDIGENOUS (Lat. native).—Applied to the plants and animals that naturally belong to a country or region. Not *exotic*, or introduced by artificial means.

ISLANDS (Lat. *insula*) occur either singly, when they are said to be *independent;* or in groups or clusters, when they constitute *archipelagoes*. They are also distinguished as continental and pelagic—*continental* when their proximity, geological character, and axial connection show them to be dependencies of the continent; and *pelagic* when far off in the ocean they rise up independently, and are generally of volcanic or coralline formation.

ISOCHEIMAL or ISOCHIMENAL (Gr. *isos*, and *cheima*, winter).—Having the same winter temperature; hence *isocheimal lines* are those drawn through such places as have the same mean winter temperature.

ISOGEOTHERMAL (Gr. *isos*, *ge*, the earth, and *therme*, heat).—Applied to lines or divisions in the earth's crust which have the same mean annual temperature, and employed as being more definite than *isothermal*, inasmuch as it refers solely to the land, whereas isothermal applies equally to air, land, and water.

ISOTHERAL (Gr. *isos*, and *theros*, summer). —Having the same summer temperature; *isotheral lines*, lines connecting all those places on the surface of the globe which have the same mean summer temperature.

ISOTHERMAL (Gr. *isos*, and *therme*, heat). —Having the same temperature; of equal temperature. In Physical Geography, *isothermal lines* are lines connecting all those places on the surface of the globe which have the same mean temperature; and as temperature is governed by relative distribution of land and water, by altitude and other conditions, places on the same parallels of latitude are often on very different isothermal lines.

K

KAROO.—A term applied to the open clayey flats of Southern Africa, which often rise terrace-like to considerable elevations, and are hard and steppe-like in the dry season, but in the wet season are speedily transformed into grassy, flower-bespangled plains. The term is thought to be derived from the Hottentot word *Karusa*, signifying "hard," and to refer to the quality of the red clayey soil, which, being impregnated with iron and mixed with sand, becomes hard as burnt clay under the influence of continued drought.

L

LACUSTRINE (Lat. *lacus*, a lake).—Of or belonging to a lake; used in contradistinction to fluviatile and marine.

LAGOON or LAGUNE (Ital. *laguna*).—Generally applied, as in the Adriatic, to shallow salt-water lakes or sheets of water cut off (or nearly so) from the sea by intervening strips of beach or river-deposit; also to the waters enclosed by circular coral-reefs; as well as to the lake-like sheets that frequently occur in tidal and periodically inundated deltas.

LAMINARIAN ZONE (*laminaria*, the sea-tangle).—That zone or belt of marine life which commences at low-water mark, and extends to a depth from forty to ninety feet, and in British seas is characterised, as its name implies, by the broad waving sea-tangle and larger algæ, by star-fishes, the common echinus, by tubularia, modiola, and pullastra.—*See* Zone.

LANDES (Fr.)—Literally, *heaths*; but applied in particular by French writers to those extensive areas of sand-drift which stretch southward from the mouth of the Garonne along the Bay of Biscay, and inwards towards Bourdeaux—hence often spoken of as the "Landes de Bourdeaux." They are extensively planted with the sea-pine (*Pinus maritimus*) on the seaward side, but stretch away inland in heathy undulating plains, chiefly occupied as sheep-runs.

LAND-LOCKED.—Applied to seas that are isolated from the rest of the ocean by peninsulas and chains of islands, as the Sea of Japan, the Sea of Okhotsk, &c. *Land-locked* seas are thus only partially enclosed or locked in by the land, while *inland* seas are surrounded on all sides by the land in a continuous manner, as the Baltic and Mediterranean.

LANDSLIP.—Any portion of high land that has slidden down to a lower level in consequence of some undermining or disturbing action. Landslips, as might be expected, are most frequent in districts subjected to earthquake disturbance, and there they sometimes take place on such a scale as materially to affect the surface configuration of the country.

LAPILLI (Lat. *lapillus*, a little stone).—A peculiar variety of volcanic cinders or slaggy concretions, abundant in some volcanic districts, and forming loose bare slopes inimical to anything like vegetation.

LATITUDE (Lat. *latitudo*, breadth).—The latitude of a place on the earth's surface is its distance from the equator, measured in degrees, minutes, and seconds along its own meridian. If in the northern hemisphere, it is said to be in North Latitude (N. Lat.); and if in the southern, in South Latitude (S. Lat.) As the distance between the equator and either of the poles is only the fourth part of the earth's circumference or 90°, the latitude of a place can never exceed that amount. *Parallels of latitude* are small circles drawn parallel to the equator; and in such a circle every place has, of course, the same latitude. The terms *longitude* and *latitude* arose from a notion of the ancients that the earth was longer from east to west than from south to north; in other words, that it had *length* and *breadth*, which these terms express.

LEEWARD.—A nautical term of frequent occurrence in geographical descriptions. In sailing, that side of a ship against which the wind blows is called her *weather-side*, while the opposite one is known as the *lee-side*. All objects on the weather-side are said to be to the *windward*, and those on the leeside to be to the *leeward* of the vessel.

LICKS.—An American term for swampy or boggy areas surrounding saline springs, the soil of which being impregnated with salt, or covered with saline incrustations, is *licked* by the wild cattle for the sake of the salt.

LITTORAL (Lat. *littus*, the sea-shore).—Belonging to, inhabiting, or taking place on the shore. Applied to operations, deposits, life, and other features which occur near the shore, in contradistinction to those of a deep-water or *pelagic* character.

LITTORAL ZONE (Lat. *littus*, the shore).—That zone of marine life which lies between high and low water mark (varying in extent according to the rise and fall of the tide, and the shallowness of the shore), and which in British seas is characterised, as the bottom may be rocky, sandy, or muddy, by such mollusca as the periwinkle, limpet, mussel, cockle, razor-shell, &c., and by such plants as the bladder-wrack, dulse, and carigeen.—*See* Zone.

LLANOS (Span.)—The flat treeless plains that extend along the banks of the Orinocco. They are, for the most part, within the tropics, and during one half of the year are covered with grass, and for the rest desolate. They are of very recent alluvial growth, and large areas being inundated during the rainy season, they are partly still in progress of formation.

LONGITUDE (Lat. *longitudo*, length).—The distance of a place measured in degrees, minutes, and seconds, east or west of any fixed meridian. In Britain, the fixed meridian is that of the Observatory of Greenwich; and in other countries it is usually that of their capitals. If the place be east of the fixed meridian, it is said to be in E. Long., and if west, in W. Long.—*See* Latitude.

M

MAREMME (Lat. *mare*, the sea).—The Italian term for those unwholesome sea-marshes that diffuse with more or less virulence their pestilential exhalations along the whole west coast of Italy.—*See* Pontine Marshes.

MESOZOIC (Gr. *mesos*, middle, and *zoe*, life).—The great division of stratified groups holding the middle forms of life, as differing from the Palæozoic and Cainozoic.

METEORIC (Gr. *meteoros*, raised above the earth).—Of or belonging to the atmosphere; and used as synonymous with *atmospheric*.

METEORIC STONES or METEORITES (Gr. *meteoros*, floating in the air).—*See* Aërolite.

METROPOLIS.—A term frequently employed by naturalists when treating of the geographical distribution of plants and animals. "Generic assemblages of plants and animals," says Edward Forbes, "whether terrestrial or aquatic, whether fresh-water or marine, have their regions, or definite geographical areas: these are what are known as 'generic areas.' Each of these has its *metropolis* or district of greatest numbers, either of typical or specific forms: geographical unity seems to be one of the essentials of every generic group."

MILE.—A well-known unit of measure, of which there are two kinds—1, The *Geographical* or *Nautical mile*, 60 of which are equal to one degree of latitude; and 2, The *common or statute mile*, 69½ of which are equal to one degree. The geographical mile is about 6079 English feet; the statute mile 5280 feet.

MIRAGE (Fr.).—A meteorological phenomenon occurring most frequently on level tracts and during hot weather, and occasioned partly by the unequal rarefication of the vapour of the atmosphere, and partly by the intermixture of strata of air having different temperatures and densities. It assumes the appearance of a lake-like sheet of water, often exhibiting the reflected or inverted images of distant objects.—*See* Fata Morgana.

MIST.—The term applied to atmospheric vapour when it becomes visible in consequence of a reduction of the temperature of the air. *Mists*, *fogs*, *haars*, and the like, are common phenomena in insular and estuary-intersected countries like Great Britain and Ireland.

MOLLUSCS, MOLLUSCA (Lat. *mollis*, soft).—One of Cuvier's grand divisions of the animal kingdom, including all the "shell-fish" proper, and having reference to the circumstance that these creatures have *soft* bodies, unsupported by any internal or tegumentary framework of sufficient density to merit the name of skeleton.

MONOCOTYLEDONOUS (Gr. *monos*, one, and *kotyledon*, seed-lobe).—Plants whose fruit has only one seed-lobe, and consequently *endogenous* in growth, like palms, lilies, grasses, &c.

MONSOONS (Arabic, *moussin*, season).—The periodical or seasonal winds of the Indian Ocean—the south-west monsoon blowing, in general terms, from April to October; and the north-east, from October to April. The alternate heating and cooling of the African and Asiatic continents during the southern and northern summers are the prime producers of these periodical air-currents.

MORAINES.—The name given in Switzerland to the longitudinal mounds of stony detritus which occur at the bases and along the edges of all the great glaciers. The formation of these accumulations is thus explained by Professor Agassiz:—The glaciers, it is well known, are continually moving downwards, in consequence, probably, of the introduction of water into their fissures, which, in freezing, expands the ice; and the ice being thus loosened or detached from the rocks on which it rests, is gradually pressed forward by its own weight. In consequence of this motion, the gravel and fragments of rocks, which fall upon the glaciers from the sides of the adjacent mountains, are accumulated in longitudinal ridges or *moraines* as the glacier melts away. These moraines are termed "lateral" when they occur in long narrow spits along the sides of the glacier; "terminal" when in transverse mounds at the lower end; and "medial" when they occupy, in one long range, the middle of a valley that has once been filled by a glacier.

MOUNTAIN (Lat. *mons*).—Any portion of the earth's crust rising considerably above the surrounding surface. The term is usually applied to heights of more than 2000 feet, all beneath that amount being regarded as *hills*, and when of inconsiderable height, as *hillocks*. A *Mountain-Chain* or *mountain-range* is a series of elevations having their bases in contact, and their axes continuous over a considerable extent of country; and several ranges possessing a certain degree of parallelism, and evidently dependent on the same series of elevatory forces, constitute a *Mountain-System*.

MOYA (Span.)—A term applied in South America to the fœtid sulphurous mud discharged by certain volcanoes.

N

NADIR (Arabic, down).—As the *zenith* is that point of the heavens directly above the head of a spectator, so the *nadir* is that point diametrically opposite, or vertically beneath his feet. In other words, they are the opposite poles of the visible horizon.

NESS, NAES, or NAZE, literally *nose*.—Any promontory or sudden projection of the land into the sea; as Dungeness, Fifeness, the "Naze," &c.

NODES (Lat. *nodus*, a knot).—In Astronomy, the points where the orbit of a planet cuts the plane of the ecliptic; or generally, the points where the orbit of one planet cuts or crosses the orbit of another.

NORMAL (Lat. *norma*, a rule).—According to rule or law; obeying what is believed to be the natural law; occurring in the ordinary course of nature.

NULLAH.—A Hindostanee term for those streams, or rather stream-courses, which are mountain-torrents during the rainy season, and during the rest of the year are dry gravelly channels, with here and there a trickling of water.

O

OASIS (Egypt. *huasis*).—In Physical Geography, a green and fertile spot in a desert; adopted from the Egyptian by Herodotus, and applied to the patches of vegetation which occur around springs in the Libyan desert.

ORBIT (Lat. *orbita*, a track or path).—The course or path of a planet round the sun; generally, the course or path described by any of the heavenly bodies. The term is derived from the Latin word *orbis*, a globe or circle; hence the heavenly bodies are spoken of as *orbs*, and their courses as *orbits*, though, strictly speaking, their form is merely *spheroidal*, and their courses *elliptical*.

OROGRAPHY, OROLOGY (Gr. *oros*, a mountain).—The science which describes or treats of the mountains and mountain-systems of the globe.

OS or OSAR.—A Swedish term for those elongated hillocks or mounds of gravel belonging to the Drift or Glacial period, and which are abundantly and characteristically scattered over Sweden and the islands of the Baltic. The greater part of the gravel of these hills, which occasionally rise to 100 or 200 feet, is of small dimensions, and mixed with much sand, and they almost always exhibit a slope and a scarped side; the former being towards the north, which is the source of the detritus.

P

PALÆOZOIC (Gr. *palaios*, ancient, and *zoe*, life).—The lowest division of stratified groups as holding the most ancient forms of life, in contradistinction to the *mesozoic* and *cainozoic*.

PAMPAS.—The vast treeless plains of the Paraguay and La Plata in South America, stretching from the eastern ridge of the Andes to the shores of Buenos Ayres, and thence southwards into the deserts of Patagonia. Though treeless, they are covered with luxuriant herbage—tall grasses and thistles—and are pastured by vast herds of wild cattle and horses.

PAMPERO.—The name given in Buenos Ayres to a violent west wind, which, traversing the arid plains of the Pampas, raises whirl-clouds of dust, and carries them forward to the coast of the Atlantic. The pamperos seem to be portions of the return, or north-western trade-winds.

PARAMOS (Span.)—The name given by the Spanish settlers to the high desert tracts of the Andes in South America.

PELAGIC (Gr. *pelagos*, the deep sea).—Of or belonging to the deep sea, as distinct from littoral or estuarine.

PERIGEE (Gr. *peri*, around, about, and *ge*, the earth).—That point of a planet's orbit at which it is nearest to the earth; its *apogee* being the point at which it is farthest off.

PLATEAU (Fr.)—Literally, a platform; introduced by the French geographer Buache, and applied to any elevated and comparatively flat surface of land; a *table-land* or high level region.

PLUVIOMETER (Lat. *pluvius*, rain; *metron*, a measure).—An instrument for catching falling rain, so as to determine the amount that falls at any given locality within a given period; a rain-guage, of which there are several varieties in use by meteorologists.

POLDERS (Dutch).—The name given in Holland to the low fertile lands reclaimed by vast systems of dykes and embankments from the sea. The soil of the *polders* consists of muddy deposits, mixed with comminuted shells and fine sea sand; in other words, it is a fine marine silt, rendered fertile by the abundance of its organic debris.

POLES (Gr. *poleo*, I turn).—The extremities of the axis or imaginary line round which the earth turns in her daily rotation. They are respectively the North and South, or the *Arctic* and *Antarctic Poles;* and the districts therewith connected are known as the *Polar Regions*. By prolonging the earth's axis towards the apparent celestial concavity in which the earth rotates, we form, in like manner, the *Poles of the Heavens*, north and south; and hence the *Pole* or *Polar Star*, from its proximity to the pole of the heavenly vault.

PONTINE MARSHES.—These sea-fens, so well known and dreaded by the inhabitants of Rome and the delta of the Tiber, are occasioned, according to Admiral Smyth, by the quantity of water carried into the plain by innumerable streams that rise at the foot of the mountains to the east of Rome, which, for want of sufficient declivity, creep sluggishly over the level space, and sometimes stagnate in pools, or lose themselves in the sands. Here, fermenting with decayed vegetable matter, and acted on by a fervid climate, malaria is produced—that invisible enemy that poisons the fairest portions of Italy, otherwise so salubrious, and renders man a sufferer from his cradle to his early grave. There is every appearance that the basin of these marshes was once a gulf of the sea, which has been gradually filled up by alluvium from the mountains.—*See* Maremme.

PORTAGE (Fr.)—Applied by voyageurs to the space or watershed that lies between the navigable branches of rivers belonging to the same or different hydrographic basins, and so called from the circumstance that boats and goods have to be carried from the one branch to the other. The name is also given to those parts where, in order to avoid cataracts or dangerous rapids, the boats are unloaded, taken out of the water, carried above the obstruction, and again launched and loaded.

PRAIRIES.—The open, slightly undulating, and grassy plains of North America. Situated in the Great Central Plain, the prairies are of vast extent; some are rolling, others are flat, and level in surface; many of them are treeless, and covered only with luxuriant grass and flowers; towards the south some tracts verge into a shrubby woodland, while in the extreme north the soil is largely swampy and desert.

R

RAIN-GAUGE.—An instrument, of which there are several kinds, for ascertaining the amount of rain-fall in any given locality.

RAVINE (Lat. *ravio*, I sound hoarsely). A deep precipitous gorge, usually the narrow excavated channel of some mountain stream, and so called from the hollow murmur of its waters.

RECENT (Lat. *recens*, fresh, still growing).—In geological classification the term *Recent* is applied to all accumulations and deposits which have taken place during the human epoch, or are still in progress of formation. All accumulations and deposits whose fossil remains belong exclusively to species still existing, are, geologically speaking, "recent," though chronologically of vast antiquity.

REEF (Sax.)—A riff or ridge, usually applied to a range or ledge of rocks occurring in the sea, and only partially covered, or placed at no great depth under the surface of the water; *e.g.*, the "coral-reefs" of the Southern Ocean.

REGION.—A term often loosely applied in geography, but applicable to any large tract of sea or land which is characterised by some feature not to be found in other areas.

RÉGUR.—The native name for the cotton soil of India, which is said to cover nearly a third part of the southern peninsula, and to range northward to a great distance, and also into the Birman Empire. It occupies nearly level plains; is of a bluish-black or greenish-grey colour—from three to twenty feet in thickness; is of marvellous fertility, and evidently of alluvial origin.

RIVER (Lat. *rivus*, Gr. *reo*, I flow).—The usual name for all considerable bodies of running water that traverse the land—*streams*, *runnels*, *rivulets*, and the like, being the terms for the minor flows that feed the main river-current. *River-basin*, the whole extent of valley-shaped or basin-shaped country drained by any river and its tributaries; *e.g.*, the "basin of the Severn," the "basin of the Tay," &c. *River-plain*, any comparatively level and extensive tract traversed by one or more rivers, and apparently for the most part of alluvial origin.

ROADSTEAD or ROADS.—Usually applied to an open and exposed anchorage, where ships may ride under the lee or shelter of the land, but from which they must sail when the wind is about to blow strong from the sea.

S

SALINE (Lat. *sal*, salt).—Impregnated with salt, as "saline springs." *Saliferous*, containing or yielding salt, like the "saliferous strata" of Cheshire, in England.

SALSES.—Eruptions of hot acidulated mud from small orifices, generally in volcanic districts, and often accompanied by steam and gases at a high temperature, which act powerfully on the surrounding solid matters, disintegrating and decomposing them, and forming new compounds.

SAVANNAH or SAVANNA (Fr.)—An American term for any vast grassy plain or *prairie;* but usually applied to the great central plain of North America, which may be said to stretch, with little perceptible interruption, from the Gulf of Mexico to the Arctic Ocean.

SCAR or SCAUR (Sax.)—Any bluff precipice of rock, like the limestone "scars" of north-western Yorkshire.

SCARPED (Fr. *escarper*, to cut steep).—Having a steep face; worn or cut away so as to present a steep precipitous front like many cliffs and mountains. Hence the term *scarp* and *counter-scarp*, or *slope* and *counter-slope*, which see.

SCORIÆ (Ital. *scorià*, dross).—Applied to all accumulations of dust, ashes, cinders, and other loose fragments of rocks discharged from active volcanoes, and often presenting whole mountain-sides of barren, clinkery surface.

SCORIFORM.—In the form of, or resembling scoriæ. Applied to loose cindery aggregations, occurring in volcanic districts, and evidently of igneous origin.

SILT.—This term is properly applied to the fine impalpable mud which collects in lakes and estuaries, but is generally used to designate all calm and gradual deposits of mud, clay, or sand; hence we speak of "marine silt," "tidal silt," and of harbours being partially filled or *silted up* with tidal debris.

SILVAS or SELVAS (Lat. *silva*, a wood).—A term applied to the woodland regions of the great Aamazonian plain. Low-lying, damp, fertile in soil, and under the influences of a tropical sun, these *silvas* present the rankest luxuriance of primeval forest-growth.

SIMOOM.—An Arabic term signifying *poison*, and applied to a hot suffocating wind, which occurs in most countries bordering on sandy deserts. Coming from the arid desert, and laden with the minutest particles, it often gives a red or reddish-dun colour to the atmosphere, and thus forewarns the traveller to take shelter from the approach of its pestilential breath. In Turkey it is called the *Samieli;* in Egypt *Khamsia* (fifty), because it usually continues fifty days; and on the western coast of Africa, *Harmattan*.

SIROCCO (Arab.)—The name given to the hot parching wind which occasionally passes over Sicily and adjacent districts, and which is supposed to originate in the Sahara or Great Burning Desert of Africa.

SLOPE and COUNTER-SLOPE.—The majority of mountain-chains present on one side a long and gentle slope, and on the other a short and rapid one—the former is termed the *slope*, the latter the counter-slope. Thus the slope of the Andes is towards the Atlantic, the counter-slope towards the Pacific.

SNOW-BLANKET.—The name given by farmers and others to any considerable thickness of snow which covers the ground during winter, and helps to protect its vegetation from the severity of the frost. In continental countries, like central and northern Europe, this *blanket* is of essential service during severe and long-continued frosts in early spring.

SNOW-LIGHT or SNOW-BLINK.—The name given by voyagers and travellers in the arctic regions to the peculiar reflection that arises from fields of ice or snow. An experienced seaman, it is said, can readily distinguish by the *blink* whether the ice is newly-formed, heavy, compact, or open. The blink or snow-light of field-ice is the most lucid, and is tinged with yellow; of packed ice it is pure white; ice newly formed has a greyish blink, and a deep yellow tint indicates snow on land.

SNOW-LINE.—That line or limit of elevation at which the air permanently attains the temperature of freezing water, and at and above which the surface is perpetually covered with snow and ice. The snow-line is, of course, highest towards the equator, and gradually descends as we approach either pole.

SOLANO (Lat. *sol*, the sun).—A hot south-west wind which occasionally visits the Spanish peninsula, and, blowing from the direction of the African deserts, is regarded as a modified *sirocco*, which see.

SOLFATARA (Ital. *solfo*, sulphur).—A volcanic fissure or other orifice from which sulphureous vapours, hot mud, and steam are emitted; akin to the *fumeroles*, *hornitos*, *hervideros*, and *salses* that occur in most volcanic areas.

SOLSTICES (Lat. *sol*, the sun; *sto*, I stand).—The two extreme points of the sun's apparent course north and south of the equator, and where he appears to make a stand, going neither northward nor southward. These are the first points of Cancer and of Capricorn, and the two corresponding seasons of the year are known as the *Summer* and *Winter Solstices*.

SPOONDRIFT.—During storms at sea, the violence of the tempest is sometimes so intense as to quell the billows, and scatter the water in a heavy shower, called by the sailors *spoondrift*. On such occasions saline particles have impregnated the air to the distance of fifty miles inland.

STATION.—The region occupied by any particular plant is called its *station*, and that of any particular animal its *habitat*—each being the locality which presents the conditions most favourable to its growth and development.

STEPPES.—A Tartar term, adopted by geographers for those extensive flats or plains which occupy so large a portion of Northern Asia and Siberia. They are generally covered with long rough grass, are but partially wooded, and consist of alluvial deposits (sand, gravel, black-earth, bog-earth, &c.), all of comparatively recent formation.

STUFA.—An Icelandic term for those fissures or orifices in volcanic districts (like Hecla), from which jets of steam issue, often at a temperature much above the boiling-point of water.

SUB-AERIAL.—Literally "under the air;" applied to phenomena which take place on the earth's surface or under the open air, in contradistinction to *sub-aqueous*, or under the water.

SUB-AQUEOUS (Lat. *sub*, under; *aqua*, water).—Applied to phenomena that take place in or under the water, in contradistinction to *sub-aërial*, or those that take place under the open air.

SUBMARINE (Lat. *sub*, under, and *mare*, the sea).—Under the sea: applied to objects that have their place at some depth in the waters of the sea, at the bottom of the ocean, or covered by the waters of the ocean; as "submarine forests," "submarine volcanoes," and other analogous phenomena.

SUBMERGENCE (Lat. *submergo*, I plunge under water).—Applied to all sinkings of the land whereby its surface is brought under the waters of the ocean. Thus we have "submerged forests," "submerged islands," and so forth.

SUBSIDENCE (Lat. *sub*, under, and *sido*, I sink or settle down).—The act of sinking or settling down to a lower level. Applied in Geology to sinkings of portions of the earth's crust, which may be either gradual and scarcely perceptible over a long lapse of years, or sudden and destructive as arising from earthquake convulsions.

SURF.—The name given to the "broken water" of waves that roll and break on comparatively flat shores. The surf along certain shores in the southern hemisphere is often very violent and almost incessant.

SYSTEM (Gr. *syn*, together, and *histemi*, to stand).—Groups of objects or occurrences having such relations as permit them to be classed together, constitute a system.

T

TABLE-LAND.—Any flat or comparatively level tract of land considerably elevated above the general surface of a country. While *plains* and *valleys* are low-lying expanses but little broken by elevations and depressions, *table-lands* and *plateaux* are similar tracts, often of great altitude; *e. g.*, the table-land of Central Spain, 2300 feet; and that of Mexico, 6000 feet above the level of the ocean.

TALUS.—The loose detritus accumulated at the base of cliffs and precipices, and derived from their weathered and wasted surfaces. Where the cliffs are high, and the rocks of a wasting nature, the talus in the course of ages assumes gigantic dimensions, and its long sloping surface becomes a characteristic feature in the landscape.

TERRACE.—Any shelf or bank of land having a uniformly flat or level surface. Such terraces are produced by the operations of water, and are either ancient sea-margins (*raised beaches*), or *lake* and *river terraces;* and point to a time when the valleys in which they occur were either occupied by lakes at these heights, or had their whole surfaces at these levels, and before their rivers had worn their channels down to lower depths.

THERMAL (Gr. *therme*, heat).—Applied to hot springs and other waters whose temperature exceeds that of 60° Fahr.

TIDES.—The name given to those regular oscillations, or risings and fallings of the water of the ocean, which are occasioned by the attraction of the moon and sun, and which occur twice in the course of the lunar day (24 hours 50 minutes). The flow, or rising towards the shore, is called *flood* tide, and the fallihg away *ebb* tide. The highest point to which the flood tide attains is called *high-water*, and the lowest to which the ebb tide sinks is *low-water*. During high and low water there is a short period of rest, or no current either way, and this is called *slack-water*. When the sun and moon act in the same direction (that is, at full moon), the greatest tidal-rise will take place, and these are known as *spring-tides:* but when these luminaries are in opposition (that is, during the third and first quarters of the moon), the rise is least, and then we have *neap-tides*.

TOPOGRAPHY (Gr. *topos*, a place, and *grapho*, I describe).—A particular account of any locality, city, town, or village; in contradistinction to the general *geography* of the country in which it is situated.

TORNADO (Span. *tournar*, to turn).—A whirlwind; any violent storm or hurricane of wind, usually accompanied with thunder, lightning, and rain. Tornadoes, though excessively violent and destructive, are for the most part limited in area and of short duration.

TORRID ZONE (Lat. *torridus*, burning, scorching).—The middle zone or belt of the earth's surface, extending on each side the equator to the tropics of Cancer and Capricorn respectively; and so called from its high temperature.—*See* Zone.

TREMBLORES.—The name given by the Spanish settlers of South America to the *surface-tremors* which, in some volcanic districts, are almost of daily occurrence.

TRIBUTARY.—Applied to any stream which, directly or indirectly, contributes water to another stream. One stream falling directly into another stream becomes an *affluent* to that stream; but both may be *tributaries* to some larger current. An affluent is thus necessarily a tributary, but a tributary is not necessarily an affluent.

TROPICS, TROPICAL (Gr. *tropikos*, from *trepo*, I turn).—Those two circles on the earth's surface over which the sun seems directly to pass when he is at the greatest distance from the equator — viz., 23½ degrees, and so called because he *turns* alternately southward and northward on reaching these points in his apparent annual course or ecliptic. The extreme divergence of the ecliptic from the equator being marked by the constellations Cancer and Capricorn, the one circle is called the northern tropic or Tropic of Cancer, and the other the southern, or Tropic of Capricorn. The zone or belt of the earth within these circles is said to be "within the tropics" or "*tropical*," and constitutes the Torrid Zone of climatologists. Plants, animals, climate, and other phenomena occurring within this region are said to be *Tropical;* those on the extreme temperate verges of the region, *Subtropical.*

TYPHOON (Gr.)—Literally, a tempest or whirlwind. *Typhoons*, the name given by navigators to the hurricanes that visit, generally from June to November, the seas of Southern China, and the adjacent archipelago of the Philippines and Moluccas.

V

VALLEY (Lat. *vallis*).—Any depressed or low-lying tract of land bounded by hill or mountain ranges; and usually traversed by a stream or river which receives the drainage of the surrounding heights. We have thus "circular valleys," "longitudinal valleys," and "cross valleys," according to the configuration and disposition of the bounding heights; though, generally speaking, longitudinal valleys, taking their names from the rivers which flow through them, are the most characteristic and common. A level tract of great extent, and traversed by more rivers than one, is, properly speaking, not a valley, but a *plain;* and deep narrow river-courses, on the other hand, are more correctly designated *glens*, *ravines*, and *gorges.*

VARIABLES.—Near the equator the trade-winds, north and south of it for a certain distance, completely neutralise each other, and the zone of calms and light breezes so formed is known as the *Variables.*

VOLCANIC (*Vulcanus*, god of fire).—Igneous action apparent at the surface of the earth, in contradistinction to *Plutonic* (which see), or that taking place at great depths in the interior. *Volcanic*, as applied to rocks, embraces all igneous products of recent or modern origin, as distinct from Trappean and Granitic.

VOLCANIC FOCI (Lat. *focus*, a fire, the point of greatest intensity).—Subterranean centres of igneous action from which minor exhibitions diverge.

VOLCANO (Lat. *Vulcanus*, the god of fire).—A volcano has been described by Sir Charles Lyell "as a more or less perfectly conical hill or mountain, formed by the successive accumulations of ejected matter in a state of incandescence or high heat, and having one or more channels of communication with the interior of the earth, by which the ejections are effected."

W

WATERSPOUT. — "The waterspouts so frequently seen in the ocean originate," says Mrs Somerville, "in adjacent strata of air of different temperatures, running in opposite directions in the upper regions of the atmosphere. They condense the vapour and give it a whirling motion, so that it descends tapering to the sea below, and causes the surface of the water to ascend in a pointed spiral till it joins that from above, and then it looks like two inverted cones, being thinner in the middle than either above or below. When a waterspout has a progressive motion, the upper and under part must move in the same direction and with equal velocity, otherwise it breaks, which frequently happens."

WEATHER-GLASS.—The familiar name for the barometer, whose variations usually indicate approaching changes in the state of the weather.

WHIRLPOOL.—Any rotatory or circular motion of water produced by opposing winds and tides. The whirlpool of Maelström, on the coast of Norway, is occasioned by the meeting of tidal currents round the islands of Lofoden and Moskoe. It is a mile and a half in diameter, and so violent that its roar is heard at the distance of several leagues.

WHIRLWIND.—The name given to aërial currents that assume a rotatory, whirling, or spiral motion. They are often of great violence, but fortunately of short duration, and are most frequently caused by the meeting of two contrary winds, though sometimes by obstructions of the land, as precipitous mountains, narrow gorges, and the like. Their occurrence at sea produces *waterspouts;* on the loose sands of the desert, *sand-pillars*, and kindred phenomena.

Wind (Sax.)—The general name for aërial currents caused by the unequal heating of the atmosphere—the heated and more rarefied portions ascending, and the colder and denser flowing inwards to supply their place. Winds are divisible into three great categories—*permanent*, like the trade-winds; *periodical*, like the monsoons and the sea and land breezes; and *accidental*, when the times of their occurrence cannot be determined.

Windward.—In nautical phraseology, all objects on the weatherside of a vessel, or that against which the wind blows, are said to be to the *windward* —that is, in the direction *from* which the wind blows.—*See* Leeward.

Z

Zenith (Arabic).—In Astronomy, that point in the heavens which is vertically or right above the head of the spectator; the term *nadir* being that which denotes the opposite point, or that perpendicularly or right under his feet.

Zodiac (*zodion*, a little animal).—The name given by astronomers to the zone within which the apparent motions of the sun, moon, and all the greater planets are performed. It constitutes a belt nine degrees on either side of the ecliptic, and is so named from its containing the figures of the animals, &c., which represent the twelve signs.—*See* Signs of the Zodiac.

Zone, in Geography (Gr. *zona*, a girdle). —One of the five great belts into which the earth is supposed to be divided in respect to temperature—viz., the *torrid*, two *temperate*, and two *frigid* zones. The torrid includes all the space that lies between the tropics, or 23½ degrees on each side of the equinoctial line; the temperate from that limit to the arctic circle (66½ degrees) in each hemisphere; and the frigid zones from the Arctic circles to either pole.

Zone, in Botany.—With a view to generalise their observations on the geographical distribution of indigenous plants, botanists are in the habit of dividing the horizontal range of vegetation into *zones*, bounded by annual isothermal lines, as—1, the equatorial; 2, tropical; 3, sub-tropical; 4, warmer temperate; 5, cooler temperate; 6, sub-arctic; 7, arctic; and 8, the polar. These zones, being applicable to either hemisphere, express the climatic facies of vegetation within more precise limits than the three great zones—torrid, temperate and frigid—of the geographer.

Zone, in Zoology.—Every zone, from the shore daily covered by the tides to the greatest vital depths, being characterised by its own peculiar seaweeds and shell-fish, in a manner very analogous to the changes in the forms and species of vegetation observed in the ascent of a tropical mountain, zoologists are in the habit of speaking of certain bathymetrical zones or "zones of life regulated by depth." Thus, in the British seas, naturalists (following the late Edward Forbes) point out *four* great belts of life—the *Littoral*, the *Laminarian*, the *Coralline*, and the *Coral* (which see); or applying the principle to the life of the ocean in general, they distinguish *five* great belts of depth—viz. 1, the Littoral; 2, Circum-littoral; 3, Median; 4, Infra-median; and 5, the Abyssal or Deep-sea zone.

INDEX.

**** The figures refer to the sections of the text in which the particular term or subject occurs; G. to the Glossary, where it is still further explained.*

ABYSSINIA, plateau, or table-land of, 85.
Abyssinian mountain-system, 72.
Acclimatisation of plants, 271, G.
African "dry rivers," nature of, 172.
Africa, general aspects of, 328-334; various regions of, 329; geology, 330; climate, 331; vegetation, 332; animals, 333; inhabitants, 334.
Agricultural zones of vegetation, 269.
Airy, Professor, on the velocity of waves, 127.
Alleghany mountains of America, 77.
Alpine mountain-system, 62.
Alps, zones of vegetation on, 262.
Altai, mountain ranges, 70.
Amazon, rise, course, and delta of, 176.
American, or red variety of man, 293.
Amour, rise and development of, 182.
Andes, mountain-system of, 79.
Andes, zones of vegetation on, 260.
Animals, their distribution and habitats, 273.
Antarctic drift-currents, 142.
Antipodes, antipodal, definition of, 22, G.
Appalachian mountain-system, 77.
Archipelagoes, or island clusters, 39.
Arctic current of Atlantic, 140.
Arctic and Antarctic Oceans, nature of, 108.
Arctic river-system, 165.
Arctic zone of vegetation, 257.
Armenia, plateau or table-land of, 83.
Asia, general aspects of, 320-327; various regions of, 322; geology, 323; climate, 324; vegetation, 325; animals, 326; inhabitants, 327; civilisation, 327.
Atlantic Ocean, characteristics of, 104.
Atlantic river-system, 169.
Atlas mountain-system, 71.
Atmosphere, as a constituent of the globe, 19, G.
Atmosphere, nature and function of, 199-203.
Atmosphere, temperature of, in zones and altitude, 204.
Australasia, aspects and character of, 352-354.
Australia, aspects and character of, 352.
Australia, mountain-ranges of, 76.
Australian plains and deserts, 93.
Avalanches, nature of, 239, G.

BAROMETER and barometric pressure, 201.
Basin, river, lake, and sea-basins, 156.
Bathymetrical zones of vegetation, 267, G.
Beach or strand, nature of, 36.
Bolivia, table-land or plateau of, 86.
Boulder clay, northern or glacial drift, 31.
Brazilian mountain-system, 80.
Breezes, sea and land, cause of, 220.
British mountain-system, 59.
Buist, Dr George, on atmosphere, 202.

CALMS and variables, zone of, 215.
Cameroon mountains, Africa, 73.
Canadian lakes, their areas, 198.
Cape mountain-system, 74.
Carboniferous or coal-measure system, 31.
Caucasian or white variety of man, 289.
Caucasian mountain-system, 66.
Castile, table-land or plateau of, 84.
Centrifugal force, nature and effects of, 13.
Chalk or Cretaceous rock-system, 31.
Change, causes productive of, 306-310.
Chinese river-plains, 91.
Circles, greater and lesser, defined, 22.
Civilisation, general conditions of, 297.
Civilisation, its conditions and progress, 297-299.
Climate, causes affecting, 241-244, G.
Climates, insular and continental, 207.
Climates, insular and continental, 243.
Climatology, science of, 199.
Clouds, nature and nomenclature of, 228.
Coast-line, its proportion to land-area, 48.
Colonies of Australasia, 352-354.
Colour of sea-water, 122.
Commercial zones of vegetable products, 270.
Compressibility of water, 115.
Configuration of land, causes and consequences of, 54.

Continent or principal land masses, areas of, 38.
Continental river-systems, 189.
Contour, or horizontal outline of land, 47, G.
Co-tidal lines, sketch-map of, 131.
Courses of rivers, nature of, 158.
Crag and tail, phenomenon of, 56, G.
Crust of the earth, meaning of, 15, 25.
Currents, oceanic, their functions, 144, 145.
Currents of the ocean, nature of, 134-142.
Cyclones, nature and course of, 224, 225, G.

Danube, rise, course, and development of, 170.
Day, cause and definition of, 11.
Dew-point, nature of, 226, G.
Delta and deltoid plains, 88, G.
Deltas and deltic plains, 97, G.
Density of the globe, 15.
Depth of the ocean and seas, 116.
Depth of rivers, 163.
Development and length of rivers, 159.
Devonian, or Old Red Sandstone system, 31.
Dew, nature and formation of, 226, 227.
Dismal Swamp, description of, 94.
Distribution of land and water, 34-44.
Doldrums, zone of calms and variables, 215, G.
Domestication of animals, principles of, 281.
Drift-currents, nature of, 135.
Drosometer, or dew measurer, 226, G.

Earthquake-waves, nature of, 126.
Ebullition or boiling, nature of, 101, G.
Eburz mountain-ranges, 67.
Ecliptic, origin and definition of term, 22, G.
Economical zones of vegetable products, 270.
Equator, or line of equal division, 20, G.
Equatorial current of the Atlantic, 137: of Pacific, 141.
Equatorial zone of vegetation, 252.
Etesian winds of Europe, 222, G.
Ethiopian, negro, or black variety of man, 295.
Ethnology, or races of man, 284-299, G.
Euphrates, rise, course, and development, 186.
Europe, general aspects of, 311-319; geology, 313; climate, 314-316; vegetation, 317; animals, 318; inhabitants and civilisation, 319.
Exotic and indigenous vegetation, 250, G.

Fauna, application of the term, 247, G.
Fens or marsh-plains of England, 97, G.
Flora, application of the term, 247, G.
Fogs and mists, nature of, 228.

Ganges, rise, course, and delta of, 184.
Geography, definition of, 1.
Geography, mathematical, political, descriptive, and physical, 2.
Geology and Physical Geography, connection between, 33.
Germanic plain, description of, 89, 90.
Ghauts, eastern and western ranges, 68.
Glaciers, formation and nature of, 239.
Glaisher, Mr, on temperature of air, 205.
Granitic rocks, nature and origin of, 32.
Gravitation, nature and effects of, 13.
Great northern plain of Old World, 89.
Guinea, mountain-system of, 73.
Gulf-stream, cause and course of, 138.
Guyot, M., on variable winds, 221.
Guyot, M., quoted, 3, 320.

Habitat of an animal, 273, G.
Hail, phenomenon of, 238.
Hemispheres, continental and oceanic, 37.
Hemisphere or half-spheres described, 20.
Himalayan mountain-range, 68,
Himalayas, zones of vegetation on, 261.
Hindoo Koosh mountain-range, 67.
Hindostan, great plain of, 91.
Hoang-ho, rise and development of, 182.
Hoar or white frost, 238, G.
Hot springs, nature of, 150.
Humboldt's current, 142.
Hungarian plain, 91.
Hurricanes or tempests, nature of, 224.
Hypsometrical zones of vegetation, 260, G

Iberian or Spanish mountain-system, 60.
Icebergs and ice-floes, formation of, 239, G.
Indian Ocean, characteristics of, 107.
Indian Ocean, river-system of, 183.
Indus, rise, course, and delta of, 185,
Indigenous and exotic vegetation, 250, G.
Interdependence of plants and animals, 282.
Iran, plateau or table-land of, 83.
Islands, geographical arrangement of, 39.
Isocheimal or equal winter lines, 245.
Isotheral, or equal summer lines, 245.
Isothermal, or equal mean temperature lines, 245, G.

Japan current, course of, 142.

Kamtchatka, active volcanoes of, 70.
Karoos of Southern Africa, 74, G.
Khasia, excessive rainfall at, 232.
Kilmadjaro and Kenia mountains, 75.
Kloofs of Southern Africa, 74, G.

La Plata, rise and course of, 175.
Lakes, their functions in nature, 192, G.
Lakes and lacustrine areas, 190-198.
Land, the, its configuration, 45-54.
Land, descriptive technicalities of, 40.
Land, main subdivisions of, 38.
Land and water, relative amounts of, 35.
Land and water, their relations, 44.
Landes of France, 97, G.
Latitude and longitude defined, 23, G.
Lebanon, mountain-range of, 67.
Length and development of rivers, 159.

Life, stratum of, its dimensions, 248.
Links or sand-dunes of Scotland, 97, G.
Llanos of South America, 95, G.
Longitude and latitude defined, 23, G.
Lowlands, technicalities of, 88.
Lowlands of the world, 87-100.
Lowlands, their origin and characteristics, 99-100.
Luminosity or phosphorescence of sea, 122, 3.

Malay, or brown variety of man, 296.
Malaysia, aspects and character of, 350-351.
Man as affected by external conditions, 284-286.
Mongolian or yellow variety of man, 291.
Maury, Captain, on saltness of ocean, 110.
Mean depth of the sea, 118.
Mean elevation of continents, 53.
Mediterranean, description of, 105.
Meridians, nature and definition of, 22, G.
Mesopotamia, ancient plain of, 91.
Metamorphic system of crystalline schists, 31.
Mexico, table-land or plateau of, 86.
Mineral springs, nature of, 150.
Mississippi, rise, course, and delta of, 179.
Moisture of the atmosphere, 208.
Monsoons, nature and cause of, 218.
Month, cause and definition of, 11.
Moraines, formation and cause of, 239.
Mountain-heights, characteristics of, 56.
Mountains and mountain-systems, 55-82.
Mozambique current, course of, 141.

Natural law, its universality and permanence, 306, 357.
Neap-tides, cause and occurrence of, 129.
New Red Sandstone, Trias and Permian, 31.
New World, or western hemisphere, 38.
New Zealand, aspects and character of, 352.
Niger, rise, course, and delta of, 172.
Nile, rise, course, and development of, 173.
Nilgherri hill-range, 68.
Nilotic delta, map of, 88.
North America, general aspects of, 335-341; various regions of, 336; geological products, 337; climate, 338; vegetation, 329; animals, 340; inhabitants, 341; civilisation, 341.

Oases of the great African desert, 92, G.
Ocean, its subdivisions and their areas, 41.
Ocean-currents, their functions, 144, 145.
Ocean-currents, causes and functions of, 134-142.
Oceans and seas, their areas, &c., 101-123.
Oceania, general aspects of, 349; regions of, 349; Malaysia, 350; Australasia, 352; Polynesia, 355.
Oceanic zones of animal life, 279.
Old Red Sandstone, or Devonian system, 31.
Old World, or eastern hemisphere, 38.
Oolitic or Jurassic rock system, 31.
Orinocco, rise, course, and delta of, 177.

Pacific Ocean, characteristics of, 106.
Pacific river-system, 181.
Pampas of South America, 95, G.
Pampero, or wind of the pampas, 223, G.
Parallels, high, low, and middle, 23.
Peling mountain-range, 69.
Peninsulas, their general trending, 47.
Permian and Triassic rock-systems, 31.
Physical Geography, its aim and objects, 1-6; its theoretical and practical bearings, 6-8; qualifications for its study, 6.
Physical Geography, objects and principles of, 300-310.
Plains and deserts of the world, 87-100.
Planets, distances, revolution, and dimensions of, 11, 14.
Plants and animals, independence of, 282.
Plant-life, laws of its distribution, 251-271.
Poles, north and south, why named, 20.
Polynesia, aspects and character of, 355-356.
Post-tertiary or Recent rock-system, 31.
Prairies of North America, 94, G.
Pressure of ocean depths, 115.
Profile of land-masses, 50-54.
Puna, or dry cold wind of the Andes, 223.
Pyrenees, culminating point of, 60.
Pyrenees, zones of vegetation on, 262.

Rain, nature and formation of, 229-234.
Rainfall in different latitudes, 230.
Rainfalls, periodical, variable, and abnormal, 233-236.
Rainfalls, violent; examples of, 232.
Rainless tracts, cause of, 237.
Relative position of land, its effects, 46.
Relief or elevation of land masses, 50.
Representative species, meaning of, 280.
Rhine, rise, course and development of, 169.
Rivers, their characteristics, 155-163.
River-systems, account of, 164-189; abstract of, 189.
Roadstead, definition of, 42 G.
Rock formations, age and arrangement of, 28.
Rocks, stratified and unstratified, their formation, 26.
Rock systems, tabulation of, 29.
Rocky Mountains, system of, 78.
Rotundity of globe, proofs of, 13.

Sahara, or Great Desert of Africa, 92.
St Lawrence, rise and development of, 180.
Salt lakes of Asia, 195; of N. America, 198.
Sardo-Corsican mountain-system, 61.
Sargasso Sea, nature of, 139, G.
Sarmatian mountain-system, 64.

Satellites or secondary plants defined, 11 G.
Scandinavian mountain-system, 63.
Seaboard, physical characteristics of, 36.
Sea-water, composition and characteristics of, 110-114.
Seasons, nature and causes of, 12 G.
Selvas of South America, 95 G.
Shore-line or coast-line, nature of, 36.
Sierras of Brazil, 80.
Silurian rock-system, 31.
Simoom, dry hot wind of the desert, 222.
Sleet, formation of, 238.
Slope and counter-slope of lands, 51 G.
Snow, cause and nature of, 238.
Snow blanket, uses of, 240 G.
Snow blink, cause of, 240 G.
Snow line, altitude and curve of, 238.
Solar system, members and constitution of, 11.
Source or rise of rivers, 157.
South America, grand aspects of, 342, 349; regions of, 343; geology, 344; climate, 345; vegetation, 346; animals, 347; inhabitants, 348.
Speke on source of Nile, quoted, 173.
Spheroidal form of the earth, proofs of, 13.
Springs and streams, description of, 148-154.
Spring-tides, cause and occurrence, 129.
Stannovoi mountain-ranges, 70.
Station of a plant, meaning of, 273.
Steppes of Old World, 90, 91.
Stratified and unstratified rocks defined, 26.
Streams or rivulets, functions of, 153, 154.
Streams and springs, nature of, 148-153.
Sub-arctic zone of vegetation, 257.
Sub-tropical zones of vegetation, 254.
Sun's rays, effects of, on vegetation, 263.

TABLE-LANDS or plateaus, 83-86 G.
Tasmania, aspects and character of, 352.
Taurus and Anti-Taurus mountains, 67.
Tchnornozem, or black earth of Russia, 90.
Telegraphic plateau of Atlantic, 119 G.
Temperature, warmer and colder, zones, 255, 256.
Temperature, or heat of globe, 16-18.
Temperature of ocean, 120.
Tertiary system, description of, 31.
The earth, its general or planetary relations, 9, 23; its motions, 11; its figure and dimensions, 13; proofs of its rotundity, 13; its area and contents, 14; density, 15; temperature, 16; aerial envelope, 17; its structure and composition, 24-33
Tibet, mountain ranges of, 69.
Tibet, plateau or table-land of, 83.
Tidal wave, nature and character of, 132.
Tides, their origin and influence, 129-133 G.
Tigris, rise, course, and development, 186.
Trade winds, nature and cause of, 213.
Trappean rocks, nature and origin of, 32.
Triassic and Permian systems, 31.
Tropical zones of vegetation, 253.
Tropics, origin and definition of term, 21 G.
Tundras or frozen morasses of Siberia, 90.
Typhoons or hurricanes of Chinese Sea, 224.

UNSTRATIFIED and stratified rocks, defined, 26.
Uralian mountain-system, 65.

VALLEYS or minor plains, 96, 97.
Variable winds, account of, 221.
Vegetative character of American race, 295.
Velocity of streams and rivers, 161, 162.
Volcanic or igneous rocks, arrangement of, 30.
Volcanic rocks, nature and origin of, 32.
Volcanoes and earthquakes, map of, p. 97.
Volume or size of rivers, 160.

WATER, circulation of, 147.
Water, hard and soft, causes of, 151.
Water, nature and composition of, 101.
Water, technical subdivisions of, 42, 43.
Watershed or watersched of rivers, 156.
Waterspouts and sand-pillars, 224.
Waves, nature and character of, 124-128.
Whirlwinds, nature and causes of, 224.
Winds, nature and functions of, 210-225, G.
Wind waves, height and velocity of, 126-128.

YABLONOI mountain-range, 70.
Yang-tse-Kiang, rise and development of, 182.
Year, cause and definition of, 11.

ZONE of calms and variables, 215 G.
Zones of the earth, characteristics of, 21 G.
Zones of vegetation, 252-259.
Zoological kingdoms and provinces, 277.

THE END.

PRINTED BY WILLIAM BLACKWOOD AND SONS, EDINBURGH.

CATALOGUE

OF

MESSRS BLACKWOOD AND SONS'

PUBLICATIONS.

HISTORY OF EUROPE,
From the Commencement of the French Revolution in 1789 to the Battle of Waterloo. By SIR ARCHIBALD ALISON, Bart., D.C.L.
A NEW LIBRARY EDITION (being the Tenth), in 14 vols. demy 8vo, with Portraits, and a copious Index, £10, 10s.
ANOTHER EDITION, in crown 8vo, 20 vols., £6.
A PEOPLE'S EDITION, 12 vols., closely printed in double columns, £2, 8s., and Index Volume, 3s.

* "An extraordinary work, which has earned for itself a lasting place in the literature of the country, and within a few years found innumerable readers in every part of the globe. There is no book extant that treats so well of the period to the illustration of which Mr Alison's labours have been devoted. It exhibits great knowledge, patient research, indefatigable industry, and vast power."—*Times, Sept. 7, 1850.*

CONTINUATION OF ALISON'S HISTORY OF EUROPE,
From the Fall of Napoleon to the Accession of Louis Napoleon. By SIR ARCHIBALD ALISON, Bart., D.C.L. In 9 vols., £6, 7s. 6d. Uniform with the Library Edition of the previous work.

EPITOME OF ALISON'S HISTORY OF EUROPE.
For the Use of Schools and Young Persons. Fifteenth Edition, 7s. 6d., bound.

ATLAS TO ALISON'S HISTORY OF EUROPE;
Containing 109 Maps and Plans of Countries, Battles, Sieges, and Sea-Fights. Constructed by A. KEITH JOHNSTON, F.R.S.E. With Vocabulary of Military and Marine Terms. Demy 4to. Library Edition, £3, 3s.; People's Edition, crown 4to, £1, 11s. 6d.

LIVES OF LORD CASTLEREAGH AND SIR CHARLES STEWART, Second and Third Marquesses of Londonderry. From the Original Papers of the Family, and other sources. By SIR ARCHIBALD ALISON, Bart., D.C.L. In 3 vols. 8vo, £2, 5s.

ANNALS OF THE PENINSULAR CAMPAIGNS.
By CAPT. THOMAS HAMILTON. A New Edition. Edited by F. HARDMAN, Esq. 8vo, 16s.; and Atlas of Maps to illustrate the Campaigns, 12s.

A VISIT TO FLANDERS AND THE FIELD OF WATERLOO.
By JAMES SIMPSON, Advocate. A Revised Edition. With Two Coloured Plans of the Battle. Crown 8vo, 5s.

WELLINGTON'S CAREER:
A Military and Political Summary. By LIEUT.-COL. E. BRUCE HAMLEY, Professor of Military History and Art at the Staff College. Crown 8vo, 2s.

THE STORY OF THE CAMPAIGN OF SEBASTOPOL.
Written in the Camp. By Lieut.-Col. E. BRUCE HAMLEY. With Illustrations drawn in Camp by the Author. 8vo, 21s.

"We strongly recommend this 'Story of the Campaign' to all who would gain a just comprehension of this tremendous struggle. Of this we are perfectly sure, it is a book unlikely to be ever superseded. Its truth is of that simple and startling character which is sure of an immortal existence; nor is it paying the gallant author too high a complement to class this masterpiece of military history with the most precious of those classic records which have been bequeathed to us by the great writers of antiquity who took part in the wars they have described."—*The Press.*

THE INVASION OF THE CRIMEA:
Its Origin, and Account of its Progress down to the Death of Lord Raglan. By ALEXANDER WILLIAM KINGLAKE, M.P. Vols. I. and II., bringing the Events down to the Close of the Battle of the Alma. Fourth Edition. Price 32s. To be completed in 4 vols. 8vo.

TEN YEARS OF IMPERIALISM IN FRANCE.
Impressions of a "Flâneur." Second Edition. In 8vo, price 9s.

"There has not been published for many a day a more remarkable book on France than this, which professes to be the impressions of a Flaneur. . . . It has all the liveliness and sparkle of a work written only for amusement; it has all the solidity and weight of a State paper; and we expect for it not a little political influence as a fair, full, and masterly statement of the Imperial policy—the first and only good account that has been given to Europe of the Napoleonic system now in force."—*Times.*

FLEETS AND NAVIES.
By Captain CHARLES HAMLEY, R.M. Originally published in 'Blackwood's Magazine.' Crown 8vo, 6s.

HISTORY OF GREECE UNDER FOREIGN DOMINATION.
By GEORGE FINLAY, LL.D., Athens—viz.:

Greece under the Romans. B.C. 146 to A.D. 717. A Historical View of the Condition of the Greek Nation from its Conquest by the Romans until the Extinction of the Roman Power in the East. Second Edition, 16s.

History of the Byzantine Empire, A.D. 716 to 1204; and of the Greek Empire of Nicæa and Constantinople, A.D. 1204 to 1453. 2 vols., £1, 7s. 6d.

Mediæval Greece and Trebizond. The History of Greece, from its Conquest by the Crusaders to its Conquest by the Turks, A.D. 1204 to 1566; and the History of the Empire of Trebizond, A.D. 1204 to 1461. 12s.

Greece under Othoman and Venetian Domination. A.D. 1453 to 1821. 10s. 6d.

History of the Greek Revolution. 2 vols. 8vo, £1, 4s.

"His book is worthy to take its place among the remarkable works on Greek history, which form one of the chief glories of English scholarship. The history of Greece is but half told without it."—*London Guardian.*

THE NATIONAL CHARACTER OF THE ATHENIANS.
By JOHN BROWN PATTERSON. Edited from the Author's revision, by Professor PILLANS, of the University of Edinburgh. With a Sketch of his Life. Crown 8vo, 4s. 6d.

STUDIES IN ROMAN LAW.
With Comparative Views of the Laws of France, England, and Scotland. By Lord MACKENZIE, one of the Judges of the Court of Session in Scotland. 8vo, 12s.

"We know not in the English language where else to look for a history of the Roman law so clear, and, at the same time, so short. . . . . More improving reading, both for the general student and for the lawyer, we cannot well imagine; and there are few, even among learned professional men, who will not gather some novel information from Lord Mackenzie's simple pages."—*London Review.*

THE EIGHTEEN CHRISTIAN CENTURIES.
By the Rev. JAMES WHITE. Fourth Edition, with an Analytical Table of Contents, and a Copious Index. Post 8vo, 7s. 6d.

THE MONKS OF THE WEST,
From St Benedict to St Bernard. By the COUNT DE MONTALEMBERT. Authorised Translation. 2 vols. 8vo, 21s.

HISTORY OF FRANCE,

From the Earliest Period to the Year 1848. By the REV. JAMES WHITE, Author of 'The Eighteen Christian Centuries.' Second Edition. Post 8vo, 9s.

"An excellent and comprehensive compendium of French history, quite above the standard of a school-book, and particularly well adapted for the libraries of literary institutions."—*National Review.*

LEADERS OF THE REFORMATION:

LUTHER, CALVIN, LATIMER, and KNOX. By the REV. JOHN TULLOCH, D.D., Principal, and Primarius Professor of Theology, St Mary's College, St Andrews. Second Edition, crown 8vo, 6s. 6d.

ENGLISH PURITANISM AND ITS LEADERS:

CROMWELL, MILTON, BAXTER, and BUNYAN. By the REV. JOHN TULLOCH, D.D. Uniform with the 'Leaders of the Reformation.' 7s. 6d.

HISTORY OF THE FRENCH PROTESTANT REFUGEES.

By CHARLES WEISS, Professor of History at the Lycée Buonaparte. Translated by F. HARDMAN, Esq. 8vo, 14s.

HISTORY OF THE CHURCH OF SCOTLAND,

From the Reformation to the Revolution Settlement. By the Very REV. JOHN LEE, D.D., LL.D., Principal of the University of Edinburgh. Edited by the Rev. WILLIAM LEE. 2 vols. 8vo, 21s.

HISTORY OF SCOTLAND FROM THE REVOLUTION

To the Extinction of the last Jacobite Insurrection, 1689-1748. By JOHN HILL BURTON, Esq., Advocate. 2 vols. 8vo, reduced to 15s.

LIVES OF THE QUEENS OF SCOTLAND,

And English Princesses connected with the Regal Succession of Great Britain. By AGNES STRICKLAND. With Portraits and Historical Vignettes. Post 8vo, £4, 4s.

"Every step in Scotland is historical; the shades of the dead arise on every side; the very rocks breathe. Miss Strickland's talents as a writer, and turn of mind as an individual, in a peculiar manner fit her for painting a historical gallery of the most illustrious or dignified female characters in that land of chivalry and song."—*Blackwood's Magazine.*

MEMORIALS OF THE CASTLE OF EDINBURGH.

By JAMES GRANT, Esq. A New Edition. In crown 8vo, with 12 Engravings, 3s. 6d.

MEMOIRS OF SIR WILLIAM KIRKALDY OF GRANGE,

Governor of the Castle of Edinburgh for Mary Queen of Scots. By JAMES GRANT, Esq. Post 8vo, 10s. 6d.

MEMOIRS OF SIR JOHN HEPBURN,

Marshal of France under Louis XIII., &c. By JAMES GRANT, Esq. Post 8vo, 8s.

WORKS OF THE REV. THOMAS M'CRIE, D.D.

A New and Uniform Edition. Edited by Professor M'CRIE. 4 vols. crown 8vo, 24s. Sold separately—viz.:

LIFE OF JOHN KNOX. Containing Illustrations of the History of the Reformation in Scotland. Crown 8vo, 6s.

LIFE OF ANDREW MELVILLE. Containing Illustrations of the Ecclesiastical and Literary History of Scotland in the Sixteenth and Seventeenth Centuries. Crown 8vo, 6s.

HISTORY OF THE PROGRESS AND SUPPRESSION OF THE REFORMATION IN ITALY IN THE SIXTEENTH CENTURY. Crown 8vo, 4s.

HISTORY OF THE PROGRESS AND SUPPRESSION OF THE REFORMATION IN SPAIN IN THE SIXTEENTH CENTURY. Crown 8vo, 3s. 6d.

THE BOSCOBEL TRACTS;

Relating to the Escape of Charles the Second after the Battle of Worcester, and his subsequent Adventures. Edited by J. HUGHES, Esq., A.M. A New Edition, with additional Notes and Illustrations, including Communications from the Rev. R. H. BARHAM, Author of the 'Ingoldsby Legends.' In 8vo, with Engravings, 16s.

"'The Boscobel Tracts' is a very curious book, and about as good an example of single subject historical collections as may be found. Originally undertaken, or at least completed, at the suggestion of the late Bishop Copplestone, in 1827, it was carried out with a degree of judgment and taste not always found in works of a similar character."—*Spectator.*

LIFE OF JOHN DUKE OF MARLBOROUGH.

With some Account of his Contemporaries, and of the War of the Succession. By SIR ARCHIBALD ALISON, Bart., D.C.L. Third Edition. 2 vols. 8vo, Portraits and Maps, 30s.

THE NEW 'EXAMEN;'

Or, An Inquiry into the Evidence of certain Passages in 'Macaulay's History of England' concerning—THE DUKE OF MARLBOROUGH—THE MASSACRE OF GLENCOE—THE HIGHLANDS OF SCOTLAND—VISCOUNT DUNDEE—WILLIAM PENN. By JOHN PAGET, Esq., Barrister-at-Law. In crown 8vo, 6s.

"We certainly never saw a more damaging exposure, and it is something worth notice that much of it appeared in 'Blackwood's Magazine' during the lifetime of Lord Macaulay, but he never attempted to make any reply. The charges are so direct, and urged in such unmistakable language, that no writer who valued his character for either accuracy of fact or fairness in comment would let them remain unanswered if he had any reason to give."—*Gentleman's Magazine.*

AUTOBIOGRAPHY OF THE REV. DR CARLYLE,

Minister of Inveresk. Containing Memorials of the Men and Events of his Time. Edited by JOHN HILL BURTON. In 8vo. Third Edition, with Portrait, 14s.

"This book contains by far the most vivid picture of Scottish life and manners that has been given to the public since the days of Sir Walter Scott. In bestowing upon it this high praise, we make no exception, not even in favour of Lord Cockburn's 'Memorials'—the book which resembles it most, and which ranks next to it in interest."—*Edinburgh Review.*

MEMOIR OF THE POLITICAL LIFE OF EDMUND BURKE.

With Extracts from his Writings. By the REV. GEORGE CROLY, D.D. 2 vols. post 8vo, 18s.

CURRAN AND HIS CONTEMPORARIES.

By CHARLES PHILLIPS, Esq., A.B. A New Edition. Crown 8vo, 7s. 6d.

"Certainly one of the most extraordinary pieces of biography ever produced. . . . . . No library should be without it."—*Lord Brougham.*

"Never, perhaps, was there a more curious collection of portraits crowded before into the same canvas."—*Times.*

MEMOIR OF MRS HEMANS.

By her SISTER. With a Portrait. Fcap. 8vo, 5s.

LIFE OF THE LATE REV. JAMES ROBERTSON, D.D.,

F.R.S.E., Professor of Divinity and Ecclesiastical History in the University of Edinburgh By the REV. A. H. CHARTERIS, M.A., Minister of New-abbey. With a Portrait. 8vo, price 10s. 6d.

ESSAYS; HISTORICAL, POLITICAL, AND MISCELLANEOUS.

By SIR ARCHIBALD ALISON, Bart. 3 vols. demy 8vo, 45s.

ESSAYS IN HISTORY AND ART.

By R. H. PATTERSON. Viz.:

COLOUR IN NATURE AND ART—REAL AND IDEAL BEAUTY—SCULPTURE—ETHNOLOGY OF EUROPE—UTOPIAS—OUR INDIAN EMPIRE—THE NATIONAL LIFE OF CHINA—AN IDEAL ART-CONGRESS—BATTLE OF THE STYLES—GENIUS AND LIBERTY—YOUTH AND SUMMER—RECORDS OF THE PAST: NINEVEH AND BABYLON—INDIA: ITS CASTES AND CREEDS—"CHRISTOPHER NORTH:" IN MEMORIAM. In 1 vol. 8vo, 12s.

NORMAN SINCLAIR.
By W. E. AYTOUN, D.C.L., Author of 'Lays of the Scottish Cavaliers,' &c. &c. In 3 vols. post 8vo, 31s. 6d.

THE OLD BACHELOR IN THE OLD SCOTTISH VILLAGE.
By THOMAS AIRD. Fcap. 8vo, 4s.

SIR EDWARD BULWER LYTTON'S NOVELS.
Library Edition. Printed from a large and readable type. In Volumes of a convenient and handsome form. 8vo, 5s. each—viz.:

THE CAXTON NOVELS, 10 Volumes:
The Caxton Family. 2 vols.
My Novel. 4 vols.
What will he do with it? 4 vols.

HISTORICAL ROMANCES, 11 Volumes:
Devereux. 2 vols.
The Last Days of Pompeii. 2 vols.
Rienzi. 2 vols.
The Siege of Grenada. 1 vol.
The Last of the Barons. 2 vols.
Harold. 2 vols.

ROMANCES, 5 Volumes:
The Pilgrims of the Rhine. 1 vol.
Eugene Aram. 2 vols.
Zanoni. 2 vols.

NOVELS OF LIFE AND MANNERS, 15 Volumes:
Pelham. 2 vols.
The Disowned. 2 vols.
Paul Clifford. 2 vols.
Godolphin. 1 vol.
Ernest Maltravers—First Part. 2 vols.
Ernest Maltravers — Second Part (*i.e.* Alice.) 2 vols.
Night and Morning. 2 vols.
Lucretia. 2 vols.

"It is of the handiest of sizes; the paper is good; and the type, which seems to be new, is very clear and beautiful. There are no pictures. The whole charm of the presentment of the volume consists in its handiness, and the tempting clearness and beauty of the type, which almost converts into a pleasure the mere act of following the printer's lines, and leaves the author's mind free to exert its unobstructed force upon the reader."—*Examiner.*
"Nothing could be better as to size, type, paper, and general get-up."—*Athenæum.*

JESSIE CAMERON: A HIGHLAND STORY.
By the LADY RACHEL BUTLER. Second Edition. Small 8vo, with a Frontispiece, 2s. 6d.

SOME PASSAGES IN THE LIFE OF ADAM BLAIR,
And History of Matthew Wald. By the Author of 'Valerius.' Fcap. 8vo, 4s. cloth.

CAPTAIN CLUTTERBUCK'S CHAMPAGNE:
A West Indian Reminiscence. Post 8vo, 12s.

SCENES OF CLERICAL LIFE.
The Sad Fortunes of Amos Barton—Mr Gilfil's Love-Story—Janet's Repentance. By GEORGE ELIOT. 2 vols. fcap. 8vo, 12s.

ADAM BEDE.
By GEORGE ELIOT. 2 vols. fcap. 8vo, 12s.

THE MILL ON THE FLOSS.
By GEORGE ELIOT. 2 vols. fcap. 8vo, 12s.

SILAS MARNER: THE WEAVER OF RAVELOE.
By GEORGE ELIOT. Fcap. 8vo, 6s.

THE NOVELS OF GEORGE ELIOT.
Cheap Edition, complete in 3 vols., price 6s. each—viz.:
ADAM BEDE.
THE MILL ON THE FLOSS.
SCENES OF CLERICAL LIFE, and SILAS MARNER.

ANNALS OF THE PARISH, AND AYRSHIRE LEGATEES.
By JOHN GALT. Fcap. 8vo, 4s. cloth.

SIR ANDREW WYLIE.
By JOHN GALT. Fcap. 8vo, 4s. cloth.

THE PROVOST, AND OTHER TALES.
By JOHN GALT. Fcap. 8vo, 4s. cloth.

THE ENTAIL.
By JOHN GALT. Fcap. 8vo, 4s. cloth.

THE YOUTH AND MANHOOD OF CYRIL THORNTON.
By CAPTAIN HAMILTON. Fcap. 8vo, 4s. cloth.

LADY LEE'S WIDOWHOOD.
By LIEUT.-COL. E. B. HAMLEY. Crown 8vo, with 13 Illustrations by the Author. 6s.

THE LIFE OF MANSIE WAUCH,
Tailor in Dalkeith. By D. M. MOIR. Fcap. 8vo, 3s. cloth.

NIGHTS AT MESS, SIR FRIZZLE PUMPKIN, AND OTHER TALES. Fcap. 8vo, 3s. cloth.

KATIE STEWART: A TRUE STORY.
By MRS OLIPHANT. Fcap. 8vo, with Frontispiece and Vignette. 4s.

PEN OWEN.
Fcap. 8vo, 4s. cloth.

PENINSULAR SCENES AND SKETCHES.
Fcap. 8vo, 3s. cloth.

REGINALD DALTON.
By the Author of 'Valerius.' Fcap. 8vo, 4s. cloth.

LIFE IN THE FAR WEST.
By G. F. RUXTON, Esq. Second Edition. Fcap. 8vo, 4s.

TOM CRINGLE'S LOG.
A New Edition. With Illustrations by STANFIELD, WEIR, SKELTON, WALKER, &c., Engraved by WHYMPER. Crown 8vo, 6s.

"Everybody who has failed to read 'Tom Cringle's Log' should do so at once. The 'Quarterly Review' went so far as to say that the papers composing it, when it first appeared in 'Blackwood,' were the most brilliant series of the time, and that time one unrivalled for the number of famous magazinists existing in it. Coleridge says, in his 'Table Talk,' that the 'Log' is most excellent; and these verdicts have been ratified by generations of men and boys, and by the manifestation of Continental approval which is shown by repeated translations. The engravings illustrating the present issue are excellent."—*Standard.*

TOM CRINGLE'S LOG.
Fcap. 8vo, 4s. cloth.

THE CRUISE OF THE MIDGE.
By the Author of 'Tom Cringle's Log.' Fcap. 8vo, 4s. cloth.

CHAPTERS ON CHURCHYARDS.
By MRS SOUTHEY. Fcap. 8vo, 7s. 6d.

THE SUBALTERN.
By the Author of the 'The Chelsea Pensioners.' Fcap. 8vo, 3s. cloth.

CHRONICLES OF CARLINGFORD: SALEM CHAPEL.
Second Edition. Complete in 1 vol., price 5s.

"This story, so fresh, so powerfully written, and so tragic, stands out from among its fellows like a piece of newly-coined gold in a handful of dim commonplace shillings. Tales of pastoral experience and scenes from clerical life we have had in plenty, but the sacred things of the conventicle, the relative position of pastor and flock in a Nonconforming 'connection,' were but guessed at by the world outside, and terrible is the revelation."—*Westminster Review.*

CHRONICLES OF CARLINGFORD: THE RECTOR, AND THE DOCTOR'S FAMILY. Post 8vo, 12s.

TALES FROM BLACKWOOD.
Complete in 12 vols., bound in cloth, 18s. The Volumes are sold separately, 1s. 6d.; and may be had of most Booksellers, in Six Volumes, handsomely half-bound in red morocco.

CONTENTS.

VOL. I. The Glenmutchkin Railway.—Vanderdecken's Message Home.—The Floating Beacon.—Colonna the Painter.—Napoleon.—A Legend of Gibraltar.—The Iron Shroud.

VOL. II. Lazaro's Legacy.—A Story without a Tail.—Faustus and Queen Elizabeth.—How I became a Yeoman.—Devereux Hall.—The Metempsychosis.—College Theatricals.

VOL. III. A Reading Party in the Long Vacation.—Father Tom and the Pope.—La Petite Madelaine.—Bob Burke's Duel with Ensign Brady.—The Headsman: A Tale of Doom.—The Wearyful Woman.

VOL. IV. How I stood for the Dreepdaily Burghs.—First and Last.—The Duke's Dilemma: A Chronicle of Niesenstein.—The Old Gentleman's Teetotum.—"Woe to us when we lose the Watery Wall."—My College Friends: Charles Russell, the Gentleman Commoner.—The Magic Lay of the One-Horse Chay.

VOL. V. Adventures in Texas.—How we got Possession of the Tuileries.—Captain Paton's Lament.—The Village Doctor.—A Singular Letter from Southern Africa.

VOL. VI. My Friend the Dutchman.—My College Friends—No. II.: Horace Leicester.—The Emerald Studs.—My College Friends—No. III.: Mr W. Wellington Hurst.—Christine: A Dutch Story.—The Man in the Bell.

VOL. VII. My English Acquaintance.—The Murderer's Last Night.—Narration of Certain Uncommon Things that did formerly happen to Me, Herbert Willis, B.D.—The Wags.—The Wet Wooing: A Narrative of '98.—Ben-na-Groich.

VOL. VIII. The Surveyor's Tale. By Professor Aytoun.—The Forrest-Race Romance.—Di Vasari: A Tale of Florence.—Sigismund Fatello.—The Boxes.

VOL. IX. Rosaura: A Tale of Madrid.—Adventure in the North-West Territory.—Harry Bolton's Curacy.—The Florida Pirate.—The Pandour and his Princess.—The Beauty Draught.

VOL. X. Antonio di Carara.—The Fatal Repast.—The Vision of Cagliostro.—The First and Last Kiss.—The Smuggler's Leap.—The Haunted and the Haunters.—The Duellists.

VOL. XI. The Natolian Story-Teller.—The First and Last Crime.—John Rintoul.—Major Moss.—The Premier and his Wife.

VOL. XII. Tickler among the Thieves!—The Bridegroom of Barna.—The Involuntary Experimentalist.—Lebrun's Lawsuit.—The Snowing-up of Strath Lugas.—A Few Words on Social Philosophy.

THE WONDER-SEEKER;
Or, The History of Charles Douglas. By M. FRASER TYTLER, Author of 'Tales of the Great and Brave,' &c. A New Edition. Fcap. 8vo, 3s. 6d.

VALERIUS: A ROMAN STORY.
Fcap. 8vo, 3s. cloth.

THE DIARY OF A LATE PHYSICIAN.
By SAMUEL WARREN, D.C.L. 1 vol. crown 8vo, 5s. 6d.

TEN THOUSAND A-YEAR.
By SAMUEL WARREN, D.C.L. 2 vols. crown 8vo, 9s.

NOW AND THEN.
By SAMUEL WARREN, D.C.L. Crown 8vo, 2s. 6d.

THE LILY AND THE BEE.
By SAMUEL WARREN, D.C.L. Crown 8vo, 2s.

MISCELLANIES.
By SAMUEL WARREN, D.C.L. Crown 8vo, 5s.

WORKS OF SAMUEL WARREN, D.C.L.
Uniform Edition. 5 vols. crown 8vo, 24s.

WORKS OF PROFESSOR WILSON.
Edited by his Son-in-Law, Professor FERRIER. In 12 vols. crown 8vo, £3, 12s.

RECREATIONS OF CHRISTOPHER NORTH.
By PROFESSOR WILSON. In 2 vols. crown 8vo, 12s.

THE NOCTES AMBROSIANÆ.
By PROFESSOR WILSON. With Notes and a Glossary. In 4 vols. crown 8vo, 24s.

A CHEAP EDITION OF THE NOCTES AMBROSIANÆ.
In 12 Parts, price 1s. each, forming Four Volumes at 4s. each in cloth.

LIGHTS AND SHADOWS OF SCOTTISH LIFE.
By PROFESSOR WILSON. Fcap. 8vo, 3s. cloth.

THE TRIALS OF MARGARET LYNDSAY.
By PROFESSOR WILSON. Fcap. 8vo, 3s. cloth.

THE FORESTERS.
By PROFESSOR WILSON. Fcap. 8vo, 3s. cloth.

TALES.
By PROFESSOR WILSON. Comprising 'The Lights and Shadows of Scottish Life;' 'The Trials of Margaret Lyndsay;' and 'The Foresters.' In 1 vol. crown 8vo, 6s. cloth.

ESSAYS, CRITICAL AND IMAGINATIVE.
By PROFESSOR WILSON. 4 vols. crown 8vo, 24s.

THE BOOK-HUNTER, ETC.

By JOHN HILL BURTON. New Edition. In crown 8vo, 7s. 6d.

"A book pleasant to look at and pleasant to read—pleasant from its rich store of anecdote, its geniality, and its humour, even to persons who care little for the subjects of which it treats, but beyond measure delightful to those who are in any degree members of the above-mentioned fraternity."—*Saturday Review.*

"We have not been more amused for a long time: and every reader who takes interest in typography and its consequences will say the same, if he will begin to read; beginning, he will finish, and be sorry when it is over."—*Athenæum.*

"Mr Burton has now given us a pleasant book, full of quaint anecdote, and of a lively bookish talk. There is a quiet humour in it which is very taking, and there is a curious knowledge of books which is really very sound."—*Examiner.*

HOMER AND HIS TRANSLATORS,

And the Greek Drama. By PROFESSOR WILSON. Crown 8vo, 6s.

"But of all the criticisms on Homer which I have ever had the good fortune to read, in our own or any language, the most vivid and entirely genial are those found in the 'Essays, Critical and Imaginative,' of the late Professor Wilson."—*Mr Gladstone's Studies on Homer.*

THE SKETCHER.

By the REV. JOHN EAGLES. Originally published in 'Blackwood's Magazine.' 8vo, 10s. 6d.

"This volume, called by the appropriate name of 'The Sketcher,' is one that ought to be found in the studio of every English landscape-painter. . . . . More instructive and suggestive readings for young artists, especially landscape-painters, can scarcely be found."—*The Globe.*

ESSAYS.

By the REV. JOHN EAGLES, A.M. Oxon. Originally published in 'Blackwood's Magazine.' Post 8vo, 10s. 6d.

CONTENTS:—Church Music, and other Parochials.—Medical Attendance, and other Parochials.—A few Hours at Hampton Court.—Grandfathers and Grandchildren.—Sitting for a Portrait.—Are there not Great Boasters among us?—Temperance and Teetotal Societies.—Thackeray's Lectures: Swift.—The Crystal Palace.—Civilisation: The Census.—The Beggar's Legacy.

ESSAYS; HISTORICAL, POLITICAL, AND MISCELLANEOUS.

By SIR ARCHIBALD ALISON, Bart., D.C.L. Three vols., demy 8vo, 45s.

LECTURES ON THE POETICAL LITERATURE OF THE PAST HALF-CENTURY. By D. M. MOIR. Third Edition. Fcap. 8vo, 5s.

"Exquisite in its taste and generous in its criticisms."—*Hugh Miller.*

LECTURES ON THE HISTORY OF LITERATURE,

Ancient and Modern. From the German of F. SCHLEGEL. Fcap., 5s.

"A wonderful performance—better than anything we as yet have in our own language."—*Quarterly Review.*

THE GENIUS OF HANDEL,

And the distinctive Character of his Sacred Compositions. Two Lectures. Delivered to the Members of the Edinburgh Philosophical Institution. By the VERY REV. DEAN RAMSAY, Author of 'Reminiscences of Scottish Life and Character.' In crown 8vo, 3s. 6d.

BLACKWOOD'S MAGAZINE,

From Commencement in 1817 to December 1861. Numbers 1 to 554, forming 90 Volumes. £31, 10s.

INDEX TO THE FIRST FIFTY VOLUMES OF BLACKWOOD'S MAGAZINE. 8vo, 15s.

LAYS OF THE SCOTTISH CAVALIERS,
And other Poems. By W. EDMONDSTOUNE AYTOUN, D.C.L., Professor of Rhetoric and English Literature in the University of Edinburgh. Fourteenth Edition. Fcap. 8vo, 7s. 6d.

"Professor Aytoun's 'Lays of the Scottish Cavaliers'—a volume of verse which shows that Scotland has yet a poet. Full of the true fire, it now stirs and swells like a trumpet-note—now sinks in cadences sad and wild as the wail of a Highland dirge."—*Quarterly Review.*

BOTHWELL: A POEM.
By W. EDMONDSTOUNE AYTOUN, D.C.L. Third Edition. Fcap. 8vo, 7s. 6d.

"Professor Aytoun has produced a fine poem and an able argument, and 'Bothwell' will assuredly take its stand among the classics of Scottish literature."—*The Press.*

THE BALLADS OF SCOTLAND.
Edited by Professor AYTOUN. Second Edition. 2 vols. fcap. 8vo, 12s.

"No country can boast of a richer collection of Ballads than Scotland, and no Editor for these Ballads could be found more accomplished than Professor Aytoun. He has sent forth two beautiful volumes which range with 'Percy's Reliques'—which, for completeness and accuracy, leave little to be desired—which must henceforth be considered as the standard edition of the Scottish Ballads, and which we commend as a model to any among ourselves who may think of doing like service to the English Ballads."—*Times.*

POEMS AND BALLADS OF GOETHE.
Translated by Professor AYTOUN and THEODORE MARTIN. Second Edition. Fcap. 8vo, 6s.

"There is no doubt that these are the best translations of Goethe's marvellously-cut gems which have yet been published."—*Times.*

THE BOOK OF BALLADS.
Edited by BON GAULTIER. Seventh Edition, with numerous Illustrations by DOYLE, LEECH, and CROWQUILL. Gilt edges, post 8vo, 8s. 6d.

FIRMILIAN; OR, THE STUDENT OF BADAJOS.
A Spasmodic Tragedy. By T. PERCY JONES. In small 8vo, 5s.

"Humour of a kind most rare at all times, and especially in the present day, runs through every page, and passages of true poetry and delicious versification prevent the continual play of sarcasm from becoming tedious."—*Literary Gazette.*

POETICAL WORKS OF THOMAS AIRD.
Fourth Edition. In 1 vol. fcap. 8vo, 6s.

POEMS.
By the LADY FLORA HASTINGS. Edited by her SISTER. Second Edition, with a Portrait. Fcap., 7s. 6d.

THE POEMS OF FELICIA HEMANS.
Complete in 1 vol. royal 8vo, with Portrait by FINDEN. Cheap Edition, 12s. 6d. *Another Edition*, with MEMOIR by her SISTER. Seven vols. fcap., 35s. *Another Edition*, in 6 vols., cloth, gilt edges, 24s.

The following Works of Mrs HEMANS are sold separately, bound in cloth, gilt edges, 4s. each:—
RECORDS OF WOMAN. FOREST SANCTUARY. SONGS OF THE AFFECTIONS. DRAMATIC WORKS. TALES AND HISTORIC SCENES. MORAL AND RELIGIOUS POEMS.

THE ODYSSEY OF HOMER.
Translated into English Verse in the Spenserian Stanza. By PHILIP STANHOPE WORSLEY, M.A., Scholar of Corpus Christi College. 2 vols. crown 8vo, 18s.

"Mr Worsley,—applying the Spenserian stanza, that beautiful romantic measure, to the most romantic poem of the ancient world—making the stanza yield him, too (what it never yielded to Byron), its treasures of fluidity and sweet ease—above all, bringing to his task a truly poetical sense and skill,—has produced a version of the 'Odyssey' much the most pleasing of those hitherto produced, and which is delightful to read."—*Professor Arnold on Translating Homer.*

POEMS AND TRANSLATIONS.
By PHILIP STANHOPE WORSLEY, M.A., Scholar of Corpus Christi College, Oxford. Fcap. 8vo, 5s.

POEMS.
By ISA. In small 8vo, 4s. 6d.

POETICAL WORKS OF D. M. MOIR.
With Portrait, and Memoir by THOMAS AIRD. Second Edition. 2 vols. fcap. 8vo, 12s.

LECTURES ON THE POETICAL LITERATURE OF THE PAST HALF-CENTURY. By D. M. MOIR (Δ). Second Edition. Fcap. 8vo, 5s.

"A delightful volume."—*Morning Chronicle.*
"Exquisite in its taste and generous in its criticisms."—*Hugh Miller.*

THE COURSE OF TIME: A POEM.
By ROBERT POLLOK, A.M. Twenty-third Edition. Fcap. 8vo, 5s.

"Of deep and hallowed impress, full of noble thoughts and graphic conceptions—the production of a mind alive to the great relations of being, and the sublime simplicity of our religion."—*Blackwood's Magazine.*

AN ILLUSTRATED EDITION OF THE COURSE OF TIME.
In large 8vo, bound in cloth, richly gilt, 21s.

"There has been no modern poem in the English language, of the class to which the 'Course of Time' belongs, since Milton wrote, that can be compared to it. In the present instance the artistic talents of Messrs FOSTER, CLAYTON, TENNIEL, EVANS, DALZIEL, GREEN, and WOODS, have been employed in giving expression to the sublimity of the language, by equally exquisite illustrations, all of which are of the highest class."—*Bell's Messenger.*

POEMS AND BALLADS OF SCHILLER.
Translated by Sir EDWARD BULWER LYTTON, Bart. Second Edition. 8vo, 10s. 6d.

ST STEPHEN'S;
Or, Illustrations of Parliamentary Oratory. A Poem. *Comprising*—Pym—Vane—Strafford—Halifax—Shaftesbury—St John—Sir R. Walpole—Chesterfield — Carteret — Chatham — Pitt — Fox — Burke—Sheridan—Wilberforce—Wyndham—Conway—Castlereagh—William Lamb (Lord Melbourne)—Tierney — Lord Grey — O'Connell — Plunkett—Shiel—Follett—Macaulay—Peel. Second Edition. Crown 8vo, 5s.

LEGENDS, LYRICS, AND OTHER POEMS.
By B. SIMMONS. Fcap., 7s. 6d.

SIR WILLIAM CRICHTON—ATHELWOLD—GUIDONE:
Dramas by WILLIAM SMITH, Author of 'Thorndale,' &c. 32mo, 2s. 6d.

THE BIRTHDAY, AND OTHER POEMS.
By MRS SOUTHEY. Second Edition, 5s.

ILLUSTRATIONS OF THE LYRIC POETRY AND MUSIC OF SCOTLAND. By WILLIAM STENHOUSE. Originally compiled to accompany the 'Scots Musical Museum,' and now published separately, with Additional Notes and Illustrations. 8vo, 7s. 6d.

PROFESSOR WILSON'S POEMS.
Containing the 'Isle of Palms,' the 'City of the Plague,' 'Unimore,' and other Poems. Complete Edition. Crown 8vo, 6s.

POEMS AND SONGS.
By DAVID WINGATE. Second Edition. Fcap. 8vo, 5s.

"We are delighted to welcome into the brotherhood of real poets a countryman of Burns, and whose verse will go far to render the rougher Border Scottish a classic dialect in our literature."—*John Bull.*

THE PHYSICAL ATLAS OF NATURAL PHENOMENA.
By ALEXANDER KEITH JOHNSTON, F.R.S.E., &c., Geographer to the Queen for Scotland. A New and Enlarged Edition, consisting of 35 Folio Plates, and 27 smaller ones, printed in Colours, with 135 pages of Letterpress, and Index. Imperial folio, half-bound morocco, £8, 8s.

"A perfect treasure of compressed information."—*Sir John Herschel.*

THE PHYSICAL ATLAS.
By ALEXANDER KEITH JOHNSTON, F.R.S.E., &c. Reduced from the Imperial Folio. This Edition contains Twenty-five Maps, including a Palæontological and Geological Map of the British Islands, with Descriptive Letterpress, and a very copious Index. In imperial 4to, half-bound morocco, £2, 12s. 6d.

"Executed with remarkable care, and is as accurate, and, for all educational purposes, as valuable, as the splendid large work (by the same author) which has now a European reputation."—*Eclectic Review.*

A GEOLOGICAL MAP OF EUROPE.
By SIR R. I. MURCHISON, D.C.L., F.R.S., &c., Director-General of the Geological Survey of Great Britain and Ireland; and JAMES NICOL, F.R.S.E., F.G.S., Professor of Natural History in the University of Aberdeen. Constructed by ALEXANDER KEITH JOHNSTON, F.R.S.E., &c. Four Sheets imperial, beautifully printed in Colours. In Sheets, £3, 3s.; in a Cloth Case, 4to, £3, 10s.

GEOLOGICAL AND PALÆONTOLOGICAL MAP OF THE BRITISH ISLANDS, including Tables of the Fossils of the different Epochs, &c. &c., from the Sketches and Notes of Professor EDWARD FORBES. With Illustrative and Explanatory Letterpress. 21s.

GEOLOGICAL MAP OF SCOTLAND.
By JAMES NICOL, F.R.S.E., &c., Professor of Natural History in the University of Aberdeen. With Explanatory Notes. The Topography by ALEXANDER KEITH JOHNSTON, F.R.S.E., &c. Scale, 10 miles to an inch. In Cloth Case, 21s.

INTRODUCTORY TEXT-BOOK OF PHYSICAL GEOGRAPHY.
By DAVID PAGE, F.R.S.E., &c. With Illustrations and a Glossarial Index. Crown 8vo, 2s.

INTRODUCTORY TEXT-BOOK OF GEOLOGY.
By DAVID PAGE, F.R.S.E., F.G.S. With Engravings on Wood and Glossarial Index. Fifth Edition, 1s. 9d.

"It has not often been our good fortune to examine a text-book on science of which we could express an opinion so entirely favourable as we are enabled to do of Mr Page's little work."—*Athenæum.*

ADVANCED TEXT-BOOK OF GEOLOGY,
Descriptive and Industrial. By DAVID PAGE, F.R.S.E., F.G.S. With Engravings and Glossary of Scientific Terms. Third Edition, revised and enlarged, 6s.

"It is therefore with unfeigned pleasure that we record our appreciation of his 'Advanced Text-Book of Geology.' We have carefully read this truly satisfactory book, and do not hesitate to say that it is an excellent compendium of the great facts of Geology, and written in a truthful and philosophic spirit."—*Edinburgh Philosophical Journal.*

HANDBOOK OF GEOLOGICAL TERMS AND GEOLOGY.
By DAVID PAGE, F.R.S.E., F.G.S. In crown 8vo, 6s.

THE PAST AND PRESENT LIFE OF THE GLOBE:
Being a Sketch in Outline of the World's Life-System. By DAVID PAGE, F.R.S.E., F.G.S. Crown 8vo, 6s. With Fifty Illustrations, drawn and engraved expressly for this Work.

"Mr Page, whose admirable text-books of geology have already secured him a position of importance in the scientific world, will add considerably to his reputation by the present sketch, as he modestly terms it, of the Life-System, or gradual evolution of the vitality of our globe. In no manual that we are aware of have the facts and phenomena of biology been presented in at once so systematic and succinct a form, the successive manifestations of life on the earth set forth in so clear an order, or traced so vividly from the earliest organisms deep-buried in its stratified crust, to the familiar forms that now adorn and people its surface."—*Literary Gazette.*

THE GEOLOGICAL EXAMINATOR:
A Progressive Series of Questions adapted to the Introductory and Advanced Text-Books of Geology. Prepared to assist Teachers in framing their Examinations, and Students in testing their own Progress and Proficiency. By DAVID PAGE, F.R.S.E., F.G.S. Second Edition, 6d.

THE GEOLOGY OF PENNSYLVANIA:
A Government Survey; with a General View of the Geology of the United States, Essays on the Coal-Formation and its Fossils, and a Description of the Coal-Fields of North America and Great Britain. By PROFESSOR HENRY DARWIN ROGERS, F.R.S., F.G.S., Professor of Natural History in the University of Glasgow. With Seven large Maps, and numerous Illustrations engraved on Copper and on Wood. In 3 vols. royal 4to, £8, 8s.

SEA-SIDE STUDIES AT ILFRACOMBE, TENBY, THE SCILLY ISLES, AND JERSEY. By GEORGE HENRY LEWES. Second Edition. Crown 8vo, with Illustrations, and a Glossary of Technical Terms, 6s. 6d.

PHYSIOLOGY OF COMMON LIFE.
By GEORGE HENRY LEWES, Author of 'Sea-side Studies,' &c. Illustrated with numerous Engravings. 2 vols., 12s.

CHEMISTRY OF COMMON LIFE.
By PROFESSOR J. F. W. JOHNSTON. A New Edition. Edited by G. H. LEWES. With 113 Illustrations on Wood, and a Copious Index. 2 vols. crown 8vo, 11s. 6d.

NOMENCLATURE OF COLOURS,
Applicable to the Arts and Natural Sciences, to Manufactures, and other Purposes of General Utility. By D. R. HAY, F.R.S.E. 228 Examples of Colours, Hues, Tints, and Shades. 8vo, £3, 3s.

NARRATIVE OF THE EARL OF ELGIN'S MISSION TO CHINA AND JAPAN. By LAURENCE OLIPHANT, Private Secretary to Lord Elgin. Illustrated with numerous Engravings in Chromo-Lithography, Maps, and Engravings on Wood, from Original Drawings and Photographs. Second Edition. In 2 vols. 8vo, 21s.

"The volumes in which Mr Oliphant has related these transactions will be read with the strongest interest now, and deserve to retain a permanent place in the literary and historical annals of our time."—*Edinburgh Review.*

RUSSIAN SHORES OF THE BLACK SEA
In the Autumn of 1852. With a Voyage down the Volga and a Tour through the Country of the Don Cossacks. By LAURENCE OLIPHANT, Esq. 8vo, with Map and other Illustrations. Fourth Edition, 14s.

EGYPT, THE SOUDAN, AND CENTRAL AFRICA:
With Explorations from Khartoum on the White Nile to the Regions of the Equator. By JOHN PETHERICK, F.R.G.S., Her Britannic Majesty's Consul for the Soudan. In 8vo, with a Map, 16s.

NOTES ON NORTH AMERICA:
Agricultural, Economical, and Social. By PROFESSOR J. F. W. JOHNSTON. 2 vols. post 8vo, 21s.

"Professor Johnston's admirable Notes. . . . The very best manual for intelligent emigrants, whilst to the British agriculturist and general reader it conveys a more complete conception of the condition of these prosperous regions than all that has hitherto been written."—*Economist.*

A FAMILY TOUR ROUND THE COASTS OF SPAIN AND PORTUGAL during the Winter of 1860-1861. By LADY DUNBAR, of Northfield. In post 8vo, 5s.

THE ROYAL ATLAS OF MODERN GEOGRAPHY.

In a Series of entirely Original and Authentic Maps. By A. KEITH JOHNSTON, F.R.S.E., F.R.G.S., Author of the 'Physical Atlas,' &c. With a complete Index of easy reference to each Map, comprising nearly 150,000 Places contained in this Atlas. Imperial folio, half-bound in russia or morocco, £5, 15s. 6d. (Dedicated by permission to Her Majesty.)

"No one can look through Mr Keith Johnston's new Atlas without seeing that it is the best which has ever been published in this country."—*The Times.*

"Of the many noble atlases prepared by Mr Johnston and published by Messrs Blackwood & Sons, this Royal Atlas will be the most useful to the public, and will deserve to be the most popular."—*Athenæum.*

"We know no series of maps which we can more warmly recommend. The accuracy, wherever we have attempted to put it to the test, is really astonishing."—*Saturday Review.*

"The culmination of all attempts to depict the face of the world appears in the Royal Atlas, than which it is impossible to conceive anything more perfect."—*Morning Herald.*

"This is, beyond question, the most splendid and luxurious, as well as the most useful and complete, of all existing atlases."—*Guardian.*

"There has not, we believe, been produced for general public use a body of maps equal in beauty and completeness to the Royal Atlas just issued by Mr A. K. Johnston."—*Examiner.*

"An almost daily reference to, and comparison of it with others, since the publication of the first part some two years ago until now, enables us to say, without the slightest hesitation, that this is by far the most complete and authentic atlas that has yet been issued."—*Scotsman.*

"Beyond doubt the greatest geographical work of our time."—*Museum.*

INDEX GEOGRAPHICUS:

Being an Index to nearly ONE HUNDRED AND FIFTY THOUSAND NAMES OF PLACES, &c.; with their LATITUDES and LONGITUDES as given in KEITH JOHNSTON'S 'ROYAL ATLAS;' together with the COUNTRIES and SUBDIVISIONS OF THE COUNTRIES in which they are situated. In 1 vol. large 8vo., 21s.

A NEW MAP OF EUROPE.

By A. KEITH JOHNSTON, F.R.S.E. Size, 4 feet 2 inches by 3 feet 5 inches. Cloth Case, 21s.

ATLAS OF SCOTLAND.

31 Maps of the Counties of Scotland, coloured. Bound in roan, price 10s. 6d. Each County may be had separately, in Cloth Case, 1s.

KEITH JOHNSTON'S SCHOOL ATLASES:—

GENERAL AND DESCRIPTIVE GEOGRAPHY, exhibiting the Actual and Comparative Extent of all the Countries in the World, with their present Political Divisions. A New and Enlarged Edition. With a complete Index. 26 Maps. Half-bound, 12s. 6d.

PHYSICAL GEOGRAPHY, illustrating, in a Series of Original Designs, the Elementary Facts of Geology, Hydrology, Meteorology, and Natural History. A New and Enlarged Edition. 19 Maps, including coloured Geological Maps of Europe and of the British Isles. Half-bound, 12s. 6d.

CLASSICAL GEOGRAPHY, comprising, in Twenty Plates, Maps and Plans of all the important Countries and Localities referred to by Classical Authors; accompanied by a pronouncing Index of Places, by T. HARVEY, M.A. Oxon. A New and Revised Edition. Half-bound, 12s. 6d.

ASTRONOMY. Edited by J. R. HIND, Esq., F.R.A.S., &c. Notes and Descriptive Letterpress to each Plate, embodying all recent Discoveries in Astronomy. 18 Maps. Half-bound, 12s. 6d.

ELEMENTARY SCHOOL ATLAS OF GENERAL AND DESCRIPTIVE GEOGRAPHY for the Use of Junior Classes. A New and Cheaper Edition. 20 Maps, including a Map of Canaan and Palestine. Half-bound, 5s.

"They are as superior to all School Atlases within our knowledge, as were the larger works of the same Author in advance of those that preceded them."—*Educational Times.*

"Decidedly the best School Atlases we have ever seen."—*English Journal of Education.*

"The best, the fullest, the most accurate and recent, as well as artistically the most beautiful atlas that can be put into the schoolboy's hands."—*Museum, April 1863.*

A MANUAL OF MODERN GEOGRAPHY:

Mathematical, Physical, and Political. Embracing a complete Development of the River-Systems of the Globe. By the REV. ALEX. MACKAY, F.R.G.S. With Index. 7s. 6d., bound in leather.

THE BOOK OF THE FARM.

Detailing the Labours of the Farmer, Farm-Steward, Ploughman, Shepherd, Hedger, Cattle-man, Field-worker, and Dairymaid, and forming a safe Monitor for Students in Practical Agriculture. By HENRY STEPHENS, F.R.S.E. 2 vols. royal 8vo, £3, handsomely bound in cloth, with upwards of 600 Illustrations.

"The best book I have ever met with."—*Professor Johnston.*

"We have thoroughly examined these volumes; but to give a full notice of their varied and valuable contents would occupy a larger space than we can conveniently devote to their discussion; we therefore, in general terms, commend them to the careful study of every young man who wishes to become a good practical farmer."—*Times.*

"One of the completest works on agriculture of which our literature can boast."—*Agricultural Gazette.*

THE BOOK OF FARM IMPLEMENTS AND MACHINES.

By JAMES SLIGHT and R. SCOTT BURN. Edited by HENRY STEPHENS, F.R.S.E. Illustrated with 876 Engravings. Royal 8vo, uniform with the 'Book of the Farm,' half-bound, £2, 2s.

THE BOOK OF FARM BUILDINGS:

Their Arrangement and Construction. By HENRY STEPHENS, F.R.S.E., and R. SCOTT BURN. Royal 8vo, with 1045 Illustrations. Uniform with the 'Book of the Farm.' Half-bound, £1, 11s. 6d.

THE BOOK OF THE GARDEN.

By CHARLES M'INTOSH. In 2 large vols. royal 8vo, embellished with 1353 Engravings.

Each Volume may be had separately—viz.:

I. ARCHITECTURAL AND ORNAMENTAL.—On the Formation of Gardens—Construction, Heating, and Ventilation of Fruit and Plant Houses, Pits, Frames, and other Garden Structures, with Practical Details. Illustrated by 1073 Engravings, pp. 766. £2, 10s.

II. PRACTICAL GARDENING.—Directions for the Culture of the Kitchen Garden, the Hardy-fruit Garden, the Forcing Garden, and Flower Garden, including Fruit and Plant Houses, with Select Lists of Vegetables, Fruits, and Plants. Pp. 868, with 279 Engravings. £1, 17s. 6d.

"We feel justified in recommending Mr M'Intosh's two excellent volumes to the notice of the public."—*Gardeners' Chronicle.*

PRACTICAL SYSTEM OF FARM BOOK-KEEPING:

Being that recommended in the 'Book of the Farm' by H. STEPHENS. Royal 8vo, 2s. 6d. Also, SEVEN FOLIO ACCOUNT-BOOKS, printed and ruled in accordance with the System, the whole being specially adapted for keeping, by an easy and accurate method, an account of all the transactions of the Farm. A detailed Prospectus may be had from the Publishers. Price of the complete set of Eight Books, £1, 4s. 6d. Also, A LABOUR ACCOUNT OF THE ESTATE, 2s. 6d.

"We have no hesitation in saying that, of the many systems of keeping farm accounts which are now in vogue, there is not one which will bear comparison with this."—*Bell's Messenger.*

AINSLIE'S TREATISE ON LAND-SURVEYING.

A New and Enlarged Edition. Edited by WILLIAM GALBRAITH, M.A., F.R.A.S. 1 vol. 8vo, with a Volume of Plates in Quarto, 21s.

"The best book on surveying with which I am acquainted."—W. RUTHERFORD, LL.D., F.R.A.S., *Royal Military Academy, Woolwich.*

THE FORESTER:

A Practical Treatise on the Planting, Rearing, and Management of Forest Trees. By JAMES BROWN, Wood Manager to the Earl of Seafield. Third Edition, greatly enlarged, with numerous Engravings on Wood. Royal 8vo, 31s. 6d.

"Beyond all doubt this is the best work on the subject of Forestry extant."—*Gardeners' Journal.*

"The most useful guide to good arboriculture in the English language."—*Gardeners' Chronicle.*

HANDBOOK OF THE MECHANICAL ARTS,
Concerned in the Construction and Arrangement of Dwellings and other Buildings; Including Carpentry, Smith-work, Iron-framing, Brick-making, Columns, Cements, Well-sinking, Enclosing of Land, Road-making, &c. By R. SCOTT BURN. Crown 8vo, with 504 Engravings on Wood, 6s. 6d.

PROFESSOR JOHNSTON'S WORKS:—

EXPERIMENTAL AGRICULTURE. Being the Results of Past, and Suggestions for Future, Experiments in Scientific and Practical Agriculture. 8s.

ELEMENTS OF AGRICULTURAL CHEMISTRY AND GEOLOGY. Eighth Edition, 6s. 6d.

A CATECHISM OF AGRICULTURAL CHEMISTRY AND GEOLOGY. Fifty-seventh Edition. Edited by Dr VOELCKER. 1s.

ON THE USE OF LIME IN AGRICULTURE. 6s.

INSTRUCTIONS FOR THE ANALYSIS OF SOILS. Fourth Edition, 2s.

THE RELATIVE VALUE OF ROUND AND SAWN TIMBER,
Shown by means of Tables and Diagrams. By JAMES RAIT, Land-Steward at Castle-Forbes. Royal 8vo, 8s. half-bound.

THE YEAR-BOOK OF AGRICULTURAL FACTS.
1859 and 1860. Edited by R. SCOTT BURN. Fcap. 8vo, 5s. each. 1861 and 1862, 4s. each.

ELKINGTON'S SYSTEM OF DRAINING:
A Systematic Treatise on the Theory and Practice of Draining Land, adapted to the various Situations and Soils of England and Scotland, drawn up from the Communications of Joseph Elkington, by J. JOHNSTONE. 4to, 10s. 6d.

JOURNAL OF AGRICULTURE, AND TRANSACTIONS OF THE HIGHLAND AND AGRICULTURAL SOCIETY OF SCOTLAND.

OLD SERIES, 1828 to 1843, 21 vols. . . .	£3	3	0
NEW SERIES, 1843 to 1851, 8 vols. . . .	2	2	0

THE RURAL ECONOMY OF ENGLAND, SCOTLAND, AND IRELAND. By LEONCE DE LAVERGNE. Translated from the French. With Notes by a Scottish Farmer. In 8vo, 12s.

"One of the best works on the philosophy of agriculture and of agricultural political economy that has appeared."—*Spectator.*

DAIRY MANAGEMENT AND FEEDING OF MILCH COWS:
Being the recorded Experience of MRS AGNES SCOTT, Winkston, Peebles. Second Edition. Fcap., 1s.

ITALIAN IRRIGATION:
A Report addressed to the Hon. the Court of Directors of the East India Company, on the Agricultural Canals of Piedmont and Lombardy; with a Sketch of the Irrigation System of Northern and Central India. By LIEUT.-COL. BAIRD SMITH, C.B. Second Edition. 2 vols. 8vo, with Atlas in folio, 30s.

THE ARCHITECTURE OF THE FARM:
A Series of Designs for Farm Houses, Farm Steadings, Factors' Houses, and Cottages. By JOHN STARFORTH, Architect. Sixty-two Engravings. In medium 4to, £2, 2s.

"One of the most useful and beautiful additions to Messrs Blackwood's extensive and valuable library of agricultural and rural economy."—*Morning Post.*

THE YESTER DEEP LAND-CULTURE:
Being a Detailed Account of the Method of Cultivation which has been successfully practised for several years by the Marquess of Tweeddale at Yester. By HENRY STEPHENS, Esq., F.R.S.E., Author of the 'Book of the Farm.' In small 8vo, with Engravings on Wood, 4s. 6d.

A MANUAL OF PRACTICAL DRAINING.
By HENRY STEPHENS, F.R.S.E., Author of the 'Book of the Farm.' Third Edition, 8vo, 5s.

A CATECHISM OF PRACTICAL AGRICULTURE.
By HENRY STEPHENS, F.R.S.E., Author of the 'Book of the Farm,' &c. In crown 8vo, with Illustrations, 1s.

HANDY BOOK ON PROPERTY LAW.
By LORD ST LEONARDS. The Seventh Edition. To which is now added a Letter on the New Laws for obtaining an Indefeasible Title. With a Portrait of the Author, engraved by HOLL. 3s. 6d.

"Less than 200 pages serve to arm us with the ordinary precautions to which we should attend in selling, buying, mortgaging, leasing, settling, and devising estates. We are informed of our relations to our property, to our wives and children, and of our liability as trustees or executors, in a little book for the million,—a book which the author tenders to the *profanum vulgus* as even capable of 'beguiling a few hours in a railway carriage.'"—*Times.*

THE PLANTER'S GUIDE.
By SIR HENRY STEUART. A New Edition, with the Author's last Additions and Corrections. 8vo, with Engravings, 21s.

STABLE ECONOMY:
A Treatise on the Management of Horses. By JOHN STEWART, V.S. Seventh Edition, 6s. 6d.

"Will always maintain its position as a standard work upon the management of horses."—*Mark Lane Express.*

ADVICE TO PURCHASERS OF HORSES.
By JOHN STEWART, V.S. 18mo, plates, 2s. 6d.

A PRACTICAL TREATISE ON THE CULTIVATION OF THE GRAPE VINE. By WILLIAM THOMSON, Gardener to His Grace the Duke of Buccleuch, Dalkeith Park. Third Edition. 8vo, 5s.

"When books on gardening are written thus conscientiously, they are alike honourable to their author and valuable to the public."—*Lindley's Gardeners' Chronicle.*

"Want of space prevents us giving extracts, and we must therefore conclude by saying, that as the author is one of the very best grape-growers of the day, this book may be stated as being the key to his successful practice, and as such, we can with confidence recommend it as indispensable to all who wish to excel in the cultivation of the vine."—*The Florist and Pomologist.*

THE CHEMISTRY OF VEGETABLE AND ANIMAL PHYSIOLOGY. By DR J. G. MULDER, Professor of Chemistry in the University of Utrecht. With an Introduction and Notes by Professor JOHNSTON. 22 Plates. 8vo, 30s.

THE MOOR AND THE LOCH.
Containing Minute Instructions in all Highland Sports, with Wanderings over Crag and Correi, Flood and Fell. By JOHN COLQUHOUN, Esq. Third Edition. 8vo, with Illustrations, 12s. 6d.

SALMON-CASTS AND STRAY SHOTS:
Being Fly-Leaves from the Note-Book of JOHN COLQUHOUN, Esq., Author of 'The Moor and the Loch,' &c. Second Edition. Fcap. 8vo, 5s.

COQUET-DALE FISHING SONGS.
Now first collected by a North-Country Angler, with the Music of the Airs. 8vo, 5s.

THE ANGLER'S COMPANION TO THE RIVERS AND LOCHS OF SCOTLAND. By T. T. STODDART. With Map of the Fishing Streams and Lakes of Scotland. Second Edition. Crown 8vo, 8s. 6d.

"Indispensable in all time to come, as the very strength and grace of an angler's tackle and equipment in Scotland, must and will be STODDART'S ANGLER'S COMPANION."—*Blackwood's Magazine.*

RELIGION IN COMMON LIFE:
A Sermon preached in Crathie Church, October 14, 1855, before Her Majesty the Queen and Prince Albert. By the Rev. JOHN CAIRD, D.D. Published by Her Majesty's Command. Bound in cloth, 8d. Cheap Edition, 3d.

SERMONS.
By the Rev. JOHN CAIRD, D.D., Professor of Divinity in the University of Glasgow, and one of Her Majesty's Chaplains for Scotland. In crown 8vo, 5s. This Edition includes the Sermon on 'Religion in Common Life,' preached in Crathie Church, Oct. 1855, before Her Majesty the Queen and the late Prince Consort.

"They are noble sermons; and we are not sure but that, with the cultivated reader, they will gain rather than lose by being read, not heard. There is a thoughtfulness and depth about them which can hardly be appreciated, unless when they are studied at leisure: and there are so many sentences so felicitously expressed that we should grudge being hurried away from them by a raped speaker, without being allowed to enjoy them a second time."—*Fraser's Magazine.*

THE BOOK OF JOB.
By the late Rev. GEORGE CROLY, LL.D., Rector of St Stephen's, Walbrook. With a Memoir of the Author by his Son. Fcap. 8vo, 4s.

LECTURES IN DIVINITY.
By the late Rev. GEORGE HILL, D.D., Principal of St Mary's College, St Andrews. Stereotyped Edition. 8vo, 14s.

"I am not sure if I can recommend a more complete manual of Divinity."—*Dr Chalmers.*

THE MOTHER'S LEGACIE TO HER UNBORNE CHILDE.
By Mrs ELIZABETH JOCELINE. Edited by the Very Rev. Principal Lee. 32mo, 4s. 6d.

"This beautiful and touching legacie."—*Athenæum.*

"A delightful monument of the piety and high feeling of a truly noble mother."—*Morning Advertiser.*

ANALYSIS AND CRITICAL INTERPRETATION OF THE HEBREW TEXT OF THE BOOK OF GENESIS. Preceded by a Hebrew Grammar, and Dissertations on the Genuineness of the Pentateuch, and on the Structure of the Hebrew Language. By the Rev. WILLIAM PAUL, A.M. 8vo, 18s.

PRAYERS FOR SOCIAL AND FAMILY WORSHIP.
Prepared by a Committee of the General Assembly of the Church of Scotland, and specially designed for the use of Soldiers, Sailors, Colonists, Sojourners in India, and other Persons, at Home or Abroad, who are deprived of the Ordinary Services of a Christian Ministry. *Published by Authority of the Committee.* Third Edition. In crown 8vo, bound in cloth, 4s.

PRAYERS FOR SOCIAL AND FAMILY WORSHIP.
Being a Cheap Edition of the above. Fcap. 8vo, 1s. 6d.

THE CHRISTIAN LIFE,
In its Origin, Progress, and Perfection. By the Very Rev. E. B. RAMSAY, LL.D., F.R.S.E., Dean of the Diocese of Edinburgh. Crown 8vo, 9s.

THEISM: THE WITNESS OF REASON AND NATURE TO AN ALL-WISE AND BENEFICENT CREATOR. By the Rev. JOHN TULLOCH, D.D., Principal and Professor of Theology, St Mary's College, St Andrews; and one of Her Majesty's Chaplains in Ordinary in Scotland. In 1 vol. 8vo, 10s. 6d.

ON THE ORIGIN AND CONNECTION OF THE GOSPELS OF MATTHEW, MARK, AND LUKE; With Synopsis of Parallel Passages, and Critical Notes. By JAMES SMITH, Esq. of Jordanhill, F.R.S., Author of the 'Voyage and Shipwreck of St Paul.' Medium 8vo, 16s.

INSTITUTES OF METAPHYSIC: THE THEORY OF KNOWING AND BEING. By JAMES F. FERRIER, A.B. Oxon., Professor of Moral Philosophy and Political Economy, St Andrews. Second Edition. Crown 8vo, 10s. 6d.

"We have no doubt, however, that the subtlety and depth of metaphysical genius which his work betrays, its rare display of rigorous and consistent reasonings, and the inimitable precision and beauty of its style on almost every page, must secure for it a distinguished place in the history of philosophical discussion."—*Tulloch's Burnett Prize Treatise.*

LECTURES ON METAPHYSICS.
By SIR WILLIAM HAMILTON, Bart., Professor of Logic and Metaphysics in the University of Edinburgh. Edited by the Rev. H. L. MANSEL, B.D., LL.D., Waynflete Professor of Moral and Metaphysical Philosophy, Oxford; and JOHN VEITCH, M.A., Professor of Logic, Rhetoric, and Metaphysics, St Andrews. Second Edition. 2 vols. 8vo, 24s.

LECTURES ON LOGIC.
By SIR WILLIAM HAMILTON, Bart. Edited by Professors MANSEL and VEITCH. In 2 vols., 24s.

THORNDALE; OR, THE CONFLICT OF OPINIONS.
By WILLIAM SMITH, Author of 'A Discourse on Ethics,' &c. Second Edition. Crown 8vo, 10s. 6d.

"The subjects treated of, and the style—always chaste and beautiful, often attractively grand—in which they are clothed, will not fail to secure the attention of the class for whom the work is avowedly written. . . . It deals with many of those higher forms of speculation characteristic of the cultivated minds of the age."—*North British Review.*

GRAVENHURST; OR, THOUGHTS ON GOOD AND EVIL.
By WILLIAM SMITH, Author of 'Thorndale,' &c. In crown 8vo, 7s. 6d.

"One of those rare books which, being filled with noble and beautiful thoughts, deserves an attentive and thoughtful perusal."—*Westminster Review.*

A DISCOURSE ON ETHICS OF THE SCHOOL OF PALEY.
By WILLIAM SMITH, Author of 'Thorndale.' 8vo, 4s.

ON THE INFLUENCE EXERTED BY THE MIND OVER THE BODY, in the Production and Removal of Morbid and Anomalous Conditions of the Animal Economy. By JOHN GLEN, M.A. Crown 8vo, 2s. 6d.

DESCARTES ON THE METHOD OF RIGHTLY CONDUCTING THE REASON, and Seeking Truth in the Sciences. Translated from the French. 12mo, 2s.

DESCARTES' MEDITATIONS, AND SELECTIONS FROM HIS PRINCIPLES OF PHILOSOPHY. Translated from the Latin. 12mo, 3s.

NEW WORKS.

What Led to the Discovery of the Source of the Nile. By JOHN HANNING SPEKE, Captain H.M. Indian Army, Author of 'Journal of the Discovery of the Source of the Nile.' 8vo, with Frontispiece and Maps, 14s.

The Scot Abroad, and the Ancient League with France. By JOHN HILL BURTON, Author of 'The Book-Hunter.' In 2 vols. crown 8vo, 15s.

Essays on Social Subjects. From the 'Saturday Review.' In crown 8vo, price 7s. 6d.

Caxtoniana: A Series of Essays on Life, Literature, and Manners. By Sir EDWARD BULWER LYTTON, Bart. 2 vols. post 8vo, £1, 1s.

Journal of the Discovery of the Source of the Nile. By Captain J. H. SPEKE. 8vo, price 21s. With a Map of Eastern Equatorial Africa by Captain SPEKE; numerous Illustrations, chiefly from Drawings by Captain GRANT; and Portraits, Engraved on Steel, of Captains SPEKE and GRANT.

Three Months in the Southern States. April—June 1863. By Lieut.-Col. FREMANTLE. With Portraits of President DAVIS, Generals POLK, LEE, LONGSTREET, BEAUREGARD, and JOHNSTON. Crown 8vo, price 7s. 6d.

Tara: A Mahratta Tale. By Captain Meadows Taylor. 3 vols. post 8vo, price £1, 11s. 6d.

ILLUSTRATED EDITION.

Lays of the Scottish Cavaliers, and other Poems. By WILLIAM EDMONDSTOUNE AYTOUN, D.C.L. Illustrated by J. NOEL PATON, and W. H. PATON, A.R.S.A. Engraved by John Thompson, W. J. Linton, W. Thomas, J. W. Whymper, J. Cooper, W. T. Green, Dalziel Brothers, E. Evans, &c. Small Quarto, printed on Toned Paper, bound in gilt cloth, 21s.