CONTOUR-MAP OF THE WORLD.
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New and Revised Edition.

PHILIPS' ATLAS OF PHYSICAL GEOGRAPHY

Containing a Series of Maps and Diagrams illustrating the Natural Features, Climates, Various Productions, and Chief Natural Phenomena of the Globe. With Notes.

EDITED BY

WILLIAM HUGHES, F.R.G.S.

* * This Atlas is designed to accompany Professor Hughes's "Class-Book of Physical Geography."

GEORGE PHILIP & SON, PUBLISHERS, LONDON AND LIVERPOOL.
The very favourable reception accorded to the new and enlarged edition of the late Professor Hughes's "Class-Book of Modern Geography," induced the Editor to prepare the present revised and considerably-extended edition of the companion "Class-Book of Physical Geography," by the same able author.

In the Preface to the original work, Professor Hughes acknowledges his obligations, in the early portion of the volume, to the well-known work of Arnold Guyot, "The Earth and Man." The other authorities consulted are named in the footnotes.

Special attention is directed to the fact that the present Class-Book is the only Physical Geography published containing a full and complete development of the "Mountain and River Systems" of the globe—a part of the subject which has hitherto been treated in a very general, and consequently unsatisfactory, manner.

The Maps, &c., in the previous edition have been cancelled, and an entirely new and much more extensive series has been substituted.

The Examination Questions, Notes, and Index will, it is hoped, be found of service to both Teachers and Students.

Liverpool, Feb. 1886.
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CLASS-BOOK

OF

PHYSICAL GEOGRAPHY.

INTRODUCTION.

Physical Geography is the geography of the natural world: in other words, it is a description of the earth in respect of its natural features, productions, and general condition as the allotted abode of man. Such a description involves an account of the lands and seas which occupy the surface of the globe; of the varieties of climate which distinguish its different regions; the various movements and other phenomena which belong to the ocean and the atmosphere; the numerous varieties of life of which the earth is the seat; and, finally, the bearings of all these things upon the different nations of mankind, alike in their industrial, social, and political relations.

A moment's reflection serves to show that many of the topics embraced within this definition of Physical Geography are capable of being treated as distinct branches of study; and they require to be so treated, if it is intended to pursue them into their full detail. Geology, or the study of the rocks of which the earth's crust is composed; Meteorology, the science which seeks to expound the laws which regulate the atmosphere; and the different branches of Natural History, or the description of the various forms of vegetable and animal life, with many subjects of less extended importance, are all more or less closely connected with an inquiry into the natural condition of the globe. But it is not necessary, for the purposes of Physical Geography, to enter upon the detailed pursuit of these subjects. A general view of their bearings and mutual relationship, in connexion with the physical aspect of the globe, is for the most part, all that is required by the geographer. Some of the more im-
important phenomena of the ocean and the atmosphere, as the currents and trade-winds, the mountain and river systems of the globe, together with the laws that regulate climate, demand, indeed, to be studied in detail. But the general aim of Physical Geography is to give a clear account of the great natural features of the Earth, and to show how, taken in conjunction with its climate and productions, they influence the condition of Man. All the branches of natural science are intimately connected with one another. It is impossible to study any one of them without finding abundant traces of its relationship to cognate subjects of investigation. Their bearing upon the condition and prospects of civilised man, and their connexion with past stages of progress in the history of the human race, impart to such inquiries the highest kind of interest, and invest them with an added charm beyond that which is always associated with the acquisition of knowledge. Such connexion, in the case of Physical Geography, is direct and obvious, as we shall have abundant occasion to point out in the following pages.
CHAPTER I

THE EARTH AS A MEMBER OF THE SOLAR SYSTEM.

The first requisite to a due acquaintance with the physical condition of the Earth, is the knowledge of its shape, magnitude, and motions, regarded as a member of the Solar System.

1. The Planets.—The Earth constitutes one of a number of bodies which revolve in elliptical orbits round the Sun. These bodies are called planets. The Earth is one of the planets, and is the fourth in order of distance from the Sun, the three intermediate members of the system being the planets Vulcan, Mercury, and Venus. Beyond the orbit of the Earth,¹ that is, at greater distances from the Sun, are, in succession, the planets Mars, Jupiter, Saturn, Uranus, and Neptune, besides a great number of much smaller planetary bodies, (distinguished as Asteroids,) which intervene between the orbits of Mars and Jupiter.

2. Of the planets above named, all but Vulcan, Uranus, Neptune, and the minor planets, have been known and observed from the earliest period of antiquity. They are visible as shining points or stars in the heavens, and are readily distinguishable (when watched during any lengthened period, or even for a few evenings in succession) by their movement amongst the other stars. The vastly greater number of the stars which stud the sky, though they move, in common with the whole heavens, from east to west, yet always preserve the same relative position to one another. Hence it is that the constellations, or groups of stars—the well-known Great Bear, for

¹ Those planets whose orbits lie between the Sun and the Earth are known as the interior or inferior planets—those whose orbits lie beyond that of the Earth, as the exterior or superior planets. Some astronomers, however, class all those planets between the Sun and the Asteroids as interior, and the rest as exterior.
example—maintain through all ages, and under all circumstances, the same figures. The planets, on the other hand, have a movement amongst the fixed stars, and make the circuit of the heavens.

3. Uranus and Neptune, the two most distant known planets, have only been discovered within modern times, by the aid of the telescope. The former was first seen by Herschel, in 1781; the latter, at the same time, by Adams, an English astronomer, and Leverrier, a French observer, in 1846. The discovery, in 1859, by a French observer, of a telescopic planet between the orbit of Mercury and the Sun, was confirmed by observations made during the total eclipse of the Sun in 1878. The name of Vulcan was conferred upon this additional member of the solar system. The Asteroids, or smaller planetary bodies, have all been discovered within a recent period. About two hundred are now known, and the number undergoes continual increase. All of them—except Ceres and Vesta, both of which are occasionally visible—are telescopic bodies, invisible to the naked eye.

4. Some of the planets are attended by secondary planets, or satellites, which move in orbits round their primaries. Thus, the Earth is attended by the Moon, a body which is intimately connected with some problems of Physical Geography, by the influence which (as we shall see in a future page) it exerts over the waters of the ocean. In like manner, the planet Mars is attended by two satellites or Moons; Jupiter by four; Saturn by eight; Uranus by four; and Neptune by one.

5. The planets and their attendant satellites, the asteroids, and the bodies known as comets (which move in highly eccentric orbits round the sun, and most of which only become visible at lengthened intervals of time), together with the Sun, round which luminary all their movements are performed, constitute the Solar System.

6. The planets and their satellites, with the asteroids, are solid or opaque bodies, and receive their light from the Sun.

7. Form and size of the Earth.—The Earth is a globe or sphere in shape, as likewise are all the other planetary bodies. It is not, however, a perfect sphere—being slightly flattened at the poles. Hence the popular comparison of its shape to that of an orange. But the

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1 Several circumstances—chief amongst them the observed perturbations in the motion of Mercury—render it probable that not one only, but several such bodies, may ultimately be found within the region indicated.

2 Greek, aster, a star—asteroid being used as a diminutive. They are also sometimes called planetoids.—The principal asteroids are Ceres, Juno, Pallas, and Vesta.
deviation of the Earth from the figure of a perfect sphere is much less than the degree in which an orange differs from the same figure. The Earth's equatorial diameter measures 7926 miles, while its polar diameter is equal to 7899 miles, so that there is only a difference of 27 miles between the two. This difference (represented by a fraction of $\frac{1}{300}$) is quite inappreciable upon any artificial representation of the Earth, and for all practical purposes of geography the shape of the planet which we inhabit may be regarded as that of a perfect sphere. The circumference of the Earth at the equator is equal to 24,899 English miles.

8. Using round numbers, and for the sake of facilitating the retention of the figures in the memory, we may say that the Earth's circumference is about 25,000 miles, and its diameter about 8000 miles; or, in more popular language, the Earth is said to measure 25,000 miles round, and 8000 miles through. The distance from any point on the surface of the Earth to its centre is therefore about 4000 miles.

9. Motions of the Earth.—The Earth, in common with the other planets, has two distinct kinds of motion—one, a movement on its own axis, which is accomplished within twenty-four hours; the other, a revolution round the Sun, which it takes a year to perform. The former is hence called its diurnal, the latter its annual, motion. It is of the highest importance that these movements should be thoroughly understood, since many of the most influential truths of Physical Geography are intimately connected with them.

10. Diurnal Motion.—The Earth's diurnal motion consists in a rotation of the globe round its own axis, in an eastwardly direction—that is, from west to east. In virtue of this motion, every object upon the surface of the globe is continually being carried round to the eastward, making a complete circuit once within twenty-four hours.

11. The Earth's rotation on its axis is the cause of day and night. The Earth is an opaque body, and receives its light from the Sun. Only one-half of it can be in receipt of the Sun's light at any given moment—the half, that is, which is then turned towards the Sun. The opposite half of the globe is in darkness. Thus, in the accompanying figure, if S represent the Sun, and E the figure of the earth, it is obvious that only half of the circle marked as E can be receiving light at any given moment of time. The half which is on the opposite
side to the sun must be in darkness. But as the Earth makes a complete revolution on its axis within twenty-four hours, every part of its surface passes in succession into the enlightened half of the circle, and afterwards passes into the dark half. Day and night, or light and darkness, thus succeed one another within every twenty-four hours.

12. Annual Motion.—The Earth's annual motion consists in an elliptical path, or orbit, which it describes round the Sun—the source of light and heat to all the bodies of the Solar System. This annual motion occasions the seasons—spring, summer, autumn, and winter—which succeed one another according as the Earth is in different parts of its orbit.

13. The cause of the differences of heat and cold, of shorter or longer days and nights, is found in the fact that the axis of the Earth is not perpendicular to the plane of its annual motion, but is inclined to that plane at an angle of 66½° (or, more strictly, 66° 32'). Hence the line of the ecliptic,1 or apparent path of the Sun in the Heavens, makes with the line of the equator an angle of 23½°. The amount of this inclination is unvarying—the Earth's axis, in whatever part of its orbit it may be, always preserving the same direction in space. The mid-day sun is therefore vertical, in succession, to different points on the globe, these points ranging as far as 23½° upon either side of the equator, in the way that is explained in the following figures.

14. In figure 2, the Earth's axis is represented by the line P p, the letters P and p marking the places of the poles. The line E Q marks the equator. S is the Sun. The shaded portion of the Earth's figure (or that which is turned away from the Sun) is, of course, in darkness, while the other half is receiving light.

Now, in this position of the Earth relatively to the Sun, it is obvious that the line which divides the enlightened from the dark half of the globe does not coincide in position with the Earth's axis. One of the poles, and a certain space (23½°) round it, fall entirely within the enlightened half, while the other pole, and

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1 Greek, *eclipse*—a disappearance—so called because eclipses only happen when the moon's place in the heavens is either on or near this line.
a similar surrounding space ($23\frac{1}{2}^\circ$) are wholly within the dark half of the globe. In figure 3, while the same direction of the Earth's axis is preserved, precisely the reverse of the above is the case. The Sun is here upon the opposite side of the Earth. That one of the Earth's poles, P, which in the previous instance fell within the enlightened half of the circle, here falls within the shaded portion of the globe, while the opposite pole is within the enlightened half.

In other words, supposing P to represent the north, and p the south pole, in the former case the north pole, and a space of $23\frac{1}{2}^\circ$ round it, are in light, and the south pole in darkness; while in the latter, the south pole and an encircling space of $23\frac{1}{2}^\circ$ are in light, and the north pole in darkness. In either of these cases, a line drawn from the Sun directly to the earth's surface does not coincide with the equator, but falls either above or below that line. In the one case it is to the north, in the other to the south of the equator. The extreme extent of its distance from the equator is the same as that of the circles of light or darkness around either pole, or $23\frac{1}{2}^\circ$. This distance upon either side of the equator marks the place of the tropics.\(^1\)

15. Figures 4 and 5 show the relative positions of the Earth and Sun under opposite circumstances, or when the line of the Earth's axis coincides with the line which divides the enlightened and dark halves of the globe. The direction of the Earth's axis in space (indicated by the line PP) is still preserved, but the Sun is here, in either case, vertically over the line of the equator, and a line joining the poles therefore marks the division between the light and the dark halves of the Earth's surface.

\(^1\) Greek, \textit{trepō}, I turn. Because the Sun, when it has reached this, its extreme distance from the equator, turns again toward that line.
16. **The Seasons.**—In the course of the Earth's annual motion round the Sun, each of the above four positions is realised, as is shown in the diagram, figure 6. The positions of the Earth, which are here successively marked as A, B, C, D, coincide with the several positions of the Earth and Sun, shown in the separate figures 2, 3, 4, 5, and they mark the respective positions of the Earth and Sun at the times of the summer and winter solstices, and the spring and autumnal equinoxes.

17. The ellipse which is drawn round the Sun, and upon which the four figures of the earth are marked, represents the plane of the Earth's orbit—that is, the path in which its annual motion round the Sun is accomplished. In every part of this circuit the direction of the Earth's axis in space is the same—making always an angle of 66½° with the plane of its orbit—so that the lines of the ecliptic and the equator are inclined to one another at an angle of 23½°. The positions of the Earth marked A and C coincide with those shown in figures 4 and 5. The north and south poles here fall exactly on the limits of the enlightened and dark halves of the globe, and the sun is vertically over the equator. These positions mark the spring and autumn equinoxes¹—that is, the 21st March and the 21st September.

18. The positions marked (in figure 6) as B and D correspond to those shown in figures 2 and 3. At B, the north pole is wholly within the enlightened half of the circle, and the Sun is vertical over

¹ Latin, *aqua nox*. Because when the sun is in either of these positions there is equal day and night (each of twelve hours' duration) throughout the globe.
a point of the Earth which is $23\frac{1}{2}^\circ$ on the north side of the equator: this is the season of the summer solstice—that is, the summer of the northern hemisphere, when the sun attains, on the 21st June, his extreme northern limit or declination.

19. As the Earth passes through the different points of its orbit, from A to B, C, and D, and thence again to A, the different seasons of spring, summer, autumn, and winter are experienced in succession by its inhabitants, and the respective length of the days and nights in either hemisphere becomes increased, or the reverse, according to its position. The position B, which marks the midsummer of the northern hemisphere, is the midwinter of the southern half of the globe. The position D, on the other hand, which is the midwinter of the northern side of the globe, is the midsummer of that half which is to the south of the equator. So with the positions A and C: the former is the spring or vernal equinox, the latter the autumnal equinox, to the northern half of the globe. To the people of the southern hemisphere, C marks the position of the vernal, and A of the autumnal equinox.

20. The varying lengths of day and night, in every part of the globe, depend upon the place of the Earth in its orbit. Under the line of the equator alone, day and night are each, throughout the year, of exactly twelve hours' duration. In the position marked A (that of the vernal equinox), the days and nights are of equal length throughout the globe, each being of exactly twelve hours' duration. As the earth advances from A to B, the length of the days is continually increasing to all places within the northern hemisphere, and the length of the nights is undergoing correspondent decrease. In the position B (midsummer of the northern half of the globe), the difference attains its greatest extreme. During the Earth's progress from B to C, the periods of light and darkness are gradually returning to equality. The days are gradually becoming shorter, and the nights longer, at all places within the northern hemisphere, while the reverse is taking place upon the southern side of the equator. At C (the autumnal equinox), there is again equal day and night, each of exactly twelve hours' duration. During the Earth's progress from C to D, the days are gradually becoming longer, and the nights shorter, within the southern hemisphere, and the position D indicates the
midsummer of southern latitudes. The passage from D to A, again, marks an increasing length of day in the northern, and a corresponding decrease in the southern half of the globe. Thus long days and short nights characterise one half of the year in either hemisphere, and are succeeded by an opposite period of short days and lengthened hours of darkness.

21. The regions that are within $23\frac{1}{2}^\circ$ of either pole, it will be observed, are alternately in perfect light or in entire darkness, according as the Earth is in the position of the summer or winter solstice (A and D). The north pole is receiving the sun's light during the whole period of the Earth's passage from A to B and from B to C—that is, for six months of the year, during all which time the south pole is in darkness. During the remaining half of the Earth's orbit (from C to D, and from D to A), the south pole, on the other hand, is constantly receiving light, and the northern pole is in darkness. Hence, at the poles there is alternate day and night of six months' duration. And at all places that lie between the poles and a distance of $23\frac{1}{2}^\circ$ (marked, in either hemisphere, by the lines of the Arctic and Antarctic circles) there are alternate periods of light and darkness which exceed twenty-four hours in length. The effect of these conditions upon the climate of regions so situated will be seen in a future chapter.

**Examination Questions.**

1. What is meant by Physical Geography?
2. Mention some other studies with which Physical Geography is connected.
3. The Earth is one of the members of the Solar System; what other planets, besides the Earth, belong to this system?
4. By what are the planets distinguished from the fixed Stars?
5. What are the Asteroids, and how many of them are now known?
6. What is meant by Satellites? What planets are attended by them?
7. Of what shape is the Earth? State its dimensions (i.e. circumference and diameter), in round numbers.
8. What two kinds of motion has the Earth? By what terms are they distinguished?
9. What natural conditions result from the Earth's diurnal motion? Draw a figure to illustrate this.
10. What natural changes result from the Earth's annual motion? Of what fact (in reference to the direction of the Earth's axis in space) are these changes the consequence?

1 Arctic—Greek, arktos, the bear, a constellation towards the north pole, whence the term is used to signify north; Antarctic (anti arktos), opposite to the north.
11. To what distance from the Equator does the vertical position of the mid-day Sun extend? What name is given to the lines drawn round the globe, upon either side of the Equator, at that distance?

12. Draw a figure to show the position of the Sun relatively to the Earth at the time of the summer solstice, i.e., when the North Pole, and a space of 23½ degrees round it, are within the enlightened half of the globe. Also, a figure to show the reverse condition, when the South Pole falls within the enlightened half. (See figs. 2 and 3, pages 6 and 7).

13. Draw a diagram to show the position of the Earth, relatively to the Sun, at each of the four seasons—viz.: Spring, Summer, Autumn, Winter. (See fig. 6, page 8). Distinguish each figure of the Earth by the name of the season to which it is correspondent.

14. What is the length of Day and Night under the line of the Equator? What changes in the respective lengths of Day and Night occur in the Northern Hemisphere, while the Earth is advancing in its orbit from the position of Winter to Spring, and Spring to Summer? What change is at the same time in progress in the Southern Hemisphere?

15. What changes, as to duration of light and darkness, occur at either pole?

16. To what distance from the poles do alternate periods of light and darkness, exceeding twenty-four hours, extend? What name is given to circles supposed to be drawn at that point?
II.

GENERAL FEATURES OF THE EARTH'S SURFACE.

1. The superficies of the globe is equal, in round numbers, to 197,000,000 of English square miles. Nearly three-fourths of this area, about 145,500,000 square miles, are covered by the waters of the ocean, with its numerous seas and other subdivisions. The visible Land occupies little more than a fourth part of the Earth's surface. But it must be remembered that the ocean is in reality only a superficial interruption to the continuity of the land, which is prolonged beneath the waters, and rises (at intervals of greater or less frequency) above their level.

2. The Distribution of the Land and Water.—The distribution of Land and Water over the Earth's surface is exceedingly irregular, as an inspection of the Map of the World—or, better still, a careful examination of the artificial globe—shows. Looking at the Equator as a line of division, it is at once obvious that the larger portion of the Land is within the northern hemisphere. The inequality in this regard is apparent in the Old and the New Worlds alike. The whole of the European, Asiatic, and North American continents, the larger part of Africa, and a small portion of South America, are to the northward of the equator.

<table>
<thead>
<tr>
<th>NORTHERN HEMISPHERE</th>
<th>SOUTHERN HEMISPHERE</th>
</tr>
</thead>
<tbody>
<tr>
<td>Land ...........38,000,000 sq. m.</td>
<td>Land ...........13,500,000 sq. m.</td>
</tr>
<tr>
<td>Water...........60,500,000 ″</td>
<td>Water ...........85,000,000 ″</td>
</tr>
</tbody>
</table>

In all, the lands within the northern hemisphere amount to not less than three-fourths of the entire solid portion of the Earth's crust. This great preponderance of land upon the northern side of the equator is attended by many important results upon the temperature and other conditions of climate which distinguish particular regions.

3. The arrangement of Land and Water is equally irregular, if regarded in the direction of east and west, as in that of north and
The line of a great circle drawn round the globe at 20° west of Greenwich (that is, the meridian of 20° west), is commonly regarded as dividing the Earth into an Eastern and a Western hemisphere. This division is arbitrary, but it is highly useful, as serving to bring the three continents of the Old World—Europe, Asia, and Africa—into one half of the Map of the World, while the continents of North and South America fall within the other half.

**EASTERN HEMISPHERE.**

<table>
<thead>
<tr>
<th>Land</th>
<th>Water</th>
</tr>
</thead>
<tbody>
<tr>
<td>35,500,000 sq. m.</td>
<td>64,000,000</td>
</tr>
</tbody>
</table>

**WESTERN HEMISPHERE.**

<table>
<thead>
<tr>
<th>Land</th>
<th>Water</th>
</tr>
</thead>
<tbody>
<tr>
<td>16,000,000 sq. m.</td>
<td>81,500,000</td>
</tr>
</tbody>
</table>

It is at once apparent, on this arrangement, that the eastern hemisphere includes a vastly greater portion of land than the western. Not only do Europe, Asia, and Africa, fall within its limits, but it also includes Australia—the only one of the continents that is wholly to the south of the equator. The proportion of Land which falls within the eastern hemisphere is equal to nearly five-sevenths of its whole extent.

4. An arrangement still more strikingly indicative of the irregular distribution of Land and Water is obtained by regarding the British Islands as occupying a central position amidst the lands spread over one-half of the Earth's surface. If the line of a great circle everywhere 90° distant from London be used as dividing the globe into two hemispheres (of one of which London would form the central point, and of the other, a spot in the South Pacific Ocean, which coincides with the antipodes of London), it is found that the continents of the Old and New World—with the exception of a small part of South America—alike fall within the limits of a single hemisphere.

**CONTINENTAL HEMISPHERE.**

<table>
<thead>
<tr>
<th>Land</th>
<th>Water</th>
</tr>
</thead>
<tbody>
<tr>
<td>43,500,000 sq. m.</td>
<td>54,500,000</td>
</tr>
</tbody>
</table>

**OCEANIC HEMISPHERE.**

<table>
<thead>
<tr>
<th>Land</th>
<th>Water</th>
</tr>
</thead>
<tbody>
<tr>
<td>8,000,000 sq. m.</td>
<td>90,500,000</td>
</tr>
</tbody>
</table>

The lands that are included within the opposite hemisphere do not constitute more than one-eleventh part of the whole land-area of the globe.

---

1. It may be noted that London is not the actual centre of a hemisphere that includes the greatest possible proportion of the land of the globe: the exact centre is a point in St. George's Channel about midway between the opposite coasts.

2. This arrangement is readily shown on the artificial globe, by elevating the north pole 51½° above the horizon, and bringing London into the place of the zenith. No other spot can be selected which will bring so great a portion of the lands of the globe within the limits of a single hemisphere.
5. The considerations above adverted to establish three great truths in regard to the arrangement of Land and Water on the Earth's surface.

(a.) The Northern hemisphere contains a vastly greater portion of land than the Southern hemisphere, in the ratio of three to one.

(b.) The Eastern hemisphere includes a much larger portion of land than the Western half of the globe, the former being to the latter nearly in the ratio of five to two.

(c.) The division of the globe by the line of a great circle distant 90° from London exhibits a terrestrial and an oceanic hemisphere, the proportion of land within the former of which exceeds that in the latter in the ratio of ten to one.

The Northern hemisphere is hence more continental than the Southern, and the Eastern more so than the Western half of the globe. The British Islands occupy the central place in a terrestrial, and their antipodes¹ in an oceanic, hemisphere.

6. It is of scarcely less importance than the above considerations, to observe that a very large proportion of the lands on the Earth's surface fall within temperate latitudes, and are hence free alike from the extremes of heat and cold which belong to regions situated in more immediate proximity either to the equator or the poles. The proportion of land to water is much greater in the north temperate zone than in any of the other zones. A glance at the map shows how vast a portion of the Old World is included between the tropic of Cancer and the line of the Arctic Circle.

<table>
<thead>
<tr>
<th>Zones</th>
<th>Land.</th>
<th>Water.</th>
</tr>
</thead>
<tbody>
<tr>
<td>N. Frigid ......</td>
<td>2,600,000</td>
<td>5,550,000</td>
</tr>
<tr>
<td>N. Temperate</td>
<td>25,150,000</td>
<td>25,950,000</td>
</tr>
<tr>
<td>Torrid...........</td>
<td>19,400,000</td>
<td>58,000,000</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Zones</th>
<th>Land.</th>
<th>Water.</th>
</tr>
</thead>
<tbody>
<tr>
<td>S. Temperate...</td>
<td>4,300,000</td>
<td>46,800,000</td>
</tr>
<tr>
<td>S. Frigid ......</td>
<td>unascertained</td>
<td></td>
</tr>
</tbody>
</table>

The lands that are embraced within this belt of the earth—stretching in the direction of east and west, between the waters of the Pacific and Atlantic Oceans, through more than a third of the circumference of the globe—are best suited for the development of man's highest powers. The same extent of land, situated either beneath the vertical sun of the torrid zone, or exposed to the ice of the polar latitudes, would have tended to produce very different results upon the destinies of the human race.

¹ Greek, *anti*, against or opposite to; *pous*, a foot.
7. Coast-Line.—The external shape, or contour, of land and sea, is a feature deserving of careful consideration. The aspects of different regions are very various in this regard. According as the outline of a country is more or less varied, it has a greater proportionate extent of coast-line, or the reverse. Its facilities for commerce, and for the varied social intercourse and advancement associated with commerce, are in great measure dependent upon this. The Mediterranean Sea has conduced in no small measure to the civilization of mankind. It was by its means that the nations of the west first assumed their rank in the onward march of civilization—a rank which the nations of the east have never been able to dispute with them. It is hardly too much to say, with Heeren, that had an extensive heath occupied the place of this inland sea, we would yet, like the nomads of Central Asia, have been wanderers like those of Tartary and Mongolia.

8. No other portion of the globe can compare with Europe in the rich diversity of coast-line which marks its southern and western shores. The numerous peninsulas, advancing headlands, with deep and sinuous recesses between, and the many adjacent islands, with their varied aspects, which belong to the circuit of the Mediterranean coasts, have no parallel elsewhere. The tropical seas of the Eastern and Western Indies exhibit insular regions of greater magnitude, but they nowhere show the same combination of peninsula and continent, of island and land-enclosed gulf, which forms the marked characteristic of Southern Europe, nor is their situation, beneath the vertical sun of the torrid zone, so favourable to man.

9. A similar diversity belongs to the shores of Western and North-Western Europe. The Baltic and its gulfs, the seas that surround the British Islands, the gulfs which indent the shores of Holland and France, exemplify the characteristic of Europe in this regard. The Mediterranean shores alone exhibit a circuit of more than thirteen thousand miles—even without reckoning the coast-line of the numerous islands which its waters enclose. Two-thirds of this extended range of coast belong to its European side. The shores of the British Islands display a circuit of more than six thousand five hundred miles—a development of coast-line which, compared to extent of surface, is truly astonishing, and which serves in no unim-

1 About one mile of coast to every 20 square miles of area.
important measure to illustrate the maritime greatness of the British nation.

10. Of all the continents, Europe has the most extensive development of coast-line compared to its superficial extent; Africa the least. Asia has a diversified contour, especially upon its southern and eastern shores, but its vast interior is far removed from maritime influence. The peninsulas of Asia bear a very much smaller proportion to the whole extent of its mainland than do those of Europe to the entire surface of the European continent. Africa exhibits a vast solid mass, unbroken by the surrounding seas.

**COAST-LINE.**

<table>
<thead>
<tr>
<th>Continent</th>
<th>Total Length in miles</th>
</tr>
</thead>
<tbody>
<tr>
<td>Europe</td>
<td>19,500</td>
</tr>
<tr>
<td>Asia</td>
<td>35,000</td>
</tr>
<tr>
<td>Africa</td>
<td>16,000</td>
</tr>
<tr>
<td>N. America</td>
<td>24,500</td>
</tr>
<tr>
<td>S. America</td>
<td>14,500</td>
</tr>
<tr>
<td>Australia</td>
<td>10,000</td>
</tr>
</tbody>
</table>

11. Of the three continents of the Old World, Africa is the most simple in form; "it is," says Guyot, "a body without members,—a tree without branches. Asia is a mighty trunk, the members of which, however, make only a fifth of its mass. In Europe, the members overrule the principal body—the branches cover the trunk; the peninsulas form almost a third of its entire surface. Africa is closed to the ocean; Asia opens only its margins: Europe surrenders entirely to it, and is the most accessible of all."

12. Comparing the external contour of each continent with its superficial extent, we find that Europe has, in proportion to the extent of its surface, nearly three times as much coast-line as Asia, about four times as much as Africa, more than twice as much as South America, and nearly twice as much as North America. The last-named continent makes nearest approach to the typical character of Europe in this regard, especially upon its eastern or Atlantic shores.

**COAST-LINE AND AREA.**

<table>
<thead>
<tr>
<th>Continent</th>
<th>No. of sq. m. of area to 1 m. of coast</th>
</tr>
</thead>
<tbody>
<tr>
<td>Europe</td>
<td>.190</td>
</tr>
<tr>
<td>Asia</td>
<td>.500</td>
</tr>
<tr>
<td>Africa</td>
<td>.750</td>
</tr>
<tr>
<td>N. America</td>
<td>.350</td>
</tr>
<tr>
<td>S. America</td>
<td>.482</td>
</tr>
<tr>
<td>Australia</td>
<td>.300</td>
</tr>
</tbody>
</table>

1 Including the larger indentations only.
In Australia, the continent of the southern hemisphere, though the whole mass exhibits solidity of shape, yet the surrounding oceans give it a development of coast-line which, though much inferior to that of Europe, is relatively considerable. The coast-line of Australia, comparatively to its superficial dimensions, is two and a half times greater than that of the African continent, and nearly equals the proportion which is exhibited by North America.

13. Comparative Elevation of the Land.—The relief, or comparative elevation, of the land is an inquiry of vast importance to Physical Geography. The direction and slope of the lower grounds, the courses of rivers, the climate and various conditions of life, are intimately connected with this, and in great measure depend upon it.

14. The great division of the Earth's surface in this regard is into Highlands and Lowlands. The former embrace the mountain-chains which form, in many cases, the external barrier of plateaux or tablelands, as well as those extended regions of the globe to which the term "table-land" is generally applied. Many such regions reach a vast altitude above the average level of the Earth's surface. The distinction between highland and lowland tracts is, in such cases, sufficiently obvious; but it should be remembered that the one often passes by insensible degrees into the other, so that the two features—widely contrasted in their types—yet blend in some measure together. It is often difficult to draw the line at which the valley terminates, and the slope of the hill-side begins; and the great lowland plains which stretch from the shores of the ocean towards the distant interior pass gradually into regions of elevation. It is thus with the high mountain-chains. The summits of the Alps or the Himalaya are only reached by the ascent through lower chains of hills, which rise by successive stages, at first above the plain at the foot of the mountain-region, and afterwards above succeeding terraces of inferior height.

15. One law which appears to govern the distribution of the highlands of the globe is this: they are found in more or less immediate proximity to the ocean, and present their steep acclivities towards its waters. The highlands and mountain-ranges of the Asiatic continent, though they stretch over large regions of the interior, are yet much nearer to the Indian and Pacific Oceans than to the shores of the Arctic Sea. The mountains of Europe press closely upon the Mediterranean shores, and the highlands of Africa are found in proximity
Fig. 7.—Sketch-Map showing position of the principal Mountain Ranges of the World.

to the coasts. In the New World, the same feature is still more strongly marked: in North and South America alike, the higher mountain-chains belong to the shores of the Pacific, and are nowhere far removed from its waters.

16. A second law (and one which results from the above) is, that the land in either hemisphere—looked at in large masses—exhibits widely-different features in its two slopes. The one is a short and abrupt declivity, the other a long and gradual slope. The latter is suited to the formation of lengthened river-courses, the former involves shorter and more rapid streams, of torrent-like character.

17. In the Old and New Worlds alike, the shorter slope of the land is directed towards the Pacific and Indian Oceans, the longer slope toward the Atlantic and Arctic basins. In other words, in the Old World, the general slope of the land is from south to north; in the New World, from west to east. Hence results the fact that so many of the larger rivers of the globe discharge either into the Atlantic Ocean, or into the Arctic Sea, which forms a part of the Atlantic basin. In asserting this as a general rule, it is not meant to be implied that the shores of the Pacific and Indian Oceans are wanting either in lowland plains of considerable extent, or in lengthened river-courses. The great rivers of the Chinese plain, and the streams
SECTIONS — Europe (N. to S.), Asia (S. to N.), Africa (E. to W.), N. America (W. to E.), S. America (W. to E. and N. to S.).
that water the fertile lowland of Northern India, would prove the fallacy of such a dogma. Looking at the continental land-masses as a whole, the truth of the proposition is nevertheless obvious; and the following diagrams, which exhibit the comparative elevations in either hemisphere, by means of sections, which follow, in the case of the Old World, the direction of north and south, and in the New World, that of east and west, offer a convincing proof of it.

18. The accompanying sections illustrate the truth, that the same law prevails with regard to plateaux and mountain-chains alike. The highest elevations on the surface of the globe belong to the Himalaya chain, situated within the Asiatic continent, and the plateau of Tibet—the loftiest among the elevated land-masses of the globe—forms a constituent portion of that mountain-region. In the New World, the Andes exhibit the loftiest summits that are found within the western hemisphere, and the Cordilleras or chains which constitute the mountain region enclose between them the table lands of Pasco and Titicaca, which rival the plateaux of central Asia in height.

[It follows, from what has been said above, that the arrangement of the land-masses of the earth may be studied under three different aspects, viz., position, contour, and relief. These, though in some respects distinct, are yet in intimate connexion with one another, and their combined influences are of the highest importance to man. The positions established in regard to them may be thus summed up:—

1) There is more land in the Northern than in the Southern Hemisphere, and more in the Eastern than in the Western Hemisphere.

2) The most striking contrasts in the distribution of land and water result from a division of the globe marked by the line of a great circle distant 90° from London. More than nine-tenths of the land are thus shown to be within a hemisphere of which London is the central point.

3) The Atlantic coasts of either hemisphere exhibit a greater variety of contour than belongs to the shores of the other oceans.

4) Europe is characterised in a superior degree to either of the other divisions of the globe by diversity of contour, and consequent development of coast-line. Africa exhibits, beyond any other continent, the opposite type of solid and unbroken mass.

5) The land exhibits, in either continent, two great slopes—a long and a short slope. In the Old World, the longer slope is from south to north; in the New World, from west to east.

6) The highest elevations in the Old World are found in the Himalaya Mountains (Asia); the highest in the New World belong to the great chain of the Andes, in South America.]

1 The highest measured elevation on the surface of the globe is Mount Everest, one of the snow-covered summits of the Himalaya chain, on the Northern border of India.
EXAMINATION QUESTIONS.

1. To what (in round numbers) does the whole surface of the Earth amount? What proportion of this consists of Land?

2. Of the Northern and Southern Hemispheres, which contains the larger proportion of Land? Name those of the Continents which lie wholly to the north of the Equator.

3. What Meridian serves to divide the Globe into an Eastern and a Western Hemisphere? Which of the two contains the greater proportion of Land?

4. By what division of the Globe can the largest portion of Land be brought within the limits of one Hemisphere, and the largest proportion of Water within the other?

5. In which of the Zones is the proportion of Land to Water the greatest? Name some of the lands that lie within that Zone.

6. What kind of influence on the social and commercial interests of mankind has been exercised by Coast-lines? What sea in an especial manner serves to illustrate this?

7. Of the Continents, which one possesses the greatest proportionate extent of Coast-line? Which the least?

8. With reference to comparative elevation, or relief, how is the surface of the Earth divided?

9. State the general law which appears to govern the distribution of the High lands of the Globe. Illustrate this by some examples.

10. What further law (resultant from the above) determines the respective slopes of the Highland regions? State, in illustration of this, the direction of the longer slopes of the Land in the Old and New World respectively.

11. The principal truths with respect to the distribution and arrangement of the Land may be summed up in six propositions. State these.

12. What regions, of the Old and New World respectively, exhibit the highest elevations?

13. Name the highest measured elevation of the Earth’s surface, and say what proportion it bears to the radius of the Globe. What is the average elevation of each continent?

This reaches 29,000 feet (or five and a half miles) in absolute height above the sea. The highest ascertained elevation in the New World—Sorata, on the western borders of Bolivia, 24,800 feet—falls short of this by about four thousand feet. Such elevations as the above are stupendous in themselves, and as compared to the works of man they are surprisingly great. But the proportion which they bear to the general mass of the globe is insignificant in the extreme. A minute grain of sand placed upon the largest of our artificial globes more than represents the altitude and mass of Mount Everest, in comparison to the whole body of the Earth. The highest elevations on the globe are equivalent to less than a seven-hundredth part of the Earth’s radius.

The average elevation of the continents is variously given. The following estimate is perhaps the most reliable—Europe, 1,342 feet; Asia, 2,264 feet; Africa, 1,800 feet; North America, 1,496 feet; South America, 2,302 feet. How little even the most stupendous mountain-chains add to the general elevation of a continent is apparent from the fact that were the Alps evenly distributed over Europe, its mean height would be only increased by 21 feet, and that a similar distribution of the immense mass of the Himalayas and contiguous ranges, would raise the general level of Asia only 160 feet.
III.

CONSTITUENT PORTIONS OF THE EARTH'S CRUST.

1. It is not enough to notice merely the distribution of land and water on the Earth's surface. We require to know what are the component parts of the land, what laws regulate their general arrangement, and to what changes they are subject through natural agencies, if we would rightly comprehend the truths of Physical Geography. The study of the rocks which compose the successive strata of the Earth's crust, in reference to their respective ages and their various fossil contents, forms the proper subject of geology. The general truths of this science blend with those of Physical Geography. A diligent examination of the natural phenomena of the globe under its present conditions affords to the geologist the best aid in the endeavour to explain the successive changes which it has undergone in former periods.

["The materials composing the Earth's crust," (says an able writer on geology), "are rocks of various kinds—as granite, roofing-slate, marble, sandstone, coal, chalk, clay, and sand—some hard and compact, others soft and incohering. These substances do not occur indiscriminately in every part of the world, nor, when found, do they always lie in the same positions. Granite, for example, may exist in one district of a country, roofing-slate in another, coal in a third, and chalk in a fourth. Some of these rocks occur in irregular mountain-masses, while others are spread out in regular layers or courses, termed strata, from the Latin word stratum, strewn or spread out."]

2. Classification of Rocks.—The great division of the substances above referred to, as composing the Earth's exterior, is into two classes, which are designated by the terms aqueous and igneous. The latter bear evidence of having been due to the agency of fire;

1 In a geological sense—that in which the term is here used—the word "rock" is held to embrace every description of substance which goes to compose the solid portion of the Earth's surface, whether it be of hard and close texture, such as granite, soft and yielding, such as clay, or composed of loosely-aggregated particles, like sand and gravel.
the former, to the fact of their deposit by water. The aqueous rocks uniformly exhibit a series of layers, or strata, evidently resulting from their formation under water; hence they are termed sedimentary or stratified formations. The igneous rocks, on the other hand, exhibit no stratified arrangement, but appear as masses of various form, in many cases bursting through and displacing the sedimentary deposits—"here appearing as walls, filling up rents and chasms, there rising up in huge conical hills, and in another region flowing irregularly over the surface in streams of lava."

3. The Sedimentary strata.—Nearly every railway cutting offers an example of rocks formed by sedimentary deposit, and the regular layers which the solid rock, thus exposed to view, exhibits, can scarcely fail to attract the notice of even the least observant among passing travellers. The exposed hill-sides, of frequent occurrence in hilly districts, and the walls of cliff which line so many parts of our sea-coast, afford like opportunities of observing the important fact of arrangement in layers, or strata. We see around us abundant examples—in every running brook which carries down particles of earth, and deposits them in the lower portions of its bed, and in every shower of rain which washes down the particles of sand or gravel, to become spread out at the foot of a rising ground, or the base of a cliff—of the kind of agency which must have formed, by deposit under water, the various sedimentary formations. The conclusion is irresistible, that such formations must have been formed in like manner, during long prior periods of time, and that what is now dry must formerly have been under water. This conclusion is strengthened by the fact that within the rock strata are found various fossils—the petrified remains of former life, vegetable or animal. The land and the sea have, in fact, changed places. The most elevated portions of what is now the dry land of the globe were at a former period covered by the waters of the ocean, and the different forms of the land—its mountain-chains, valleys, ravines, and various altitudes or depressions—have been in great measure determined by the transporting and hollowing-out powers of running water.

4. It seldom happens that the sedimentary strata which compose so large a portion of the Earth's crust exhibit a perfectly horizontal arrangement through any lengthened distance. More frequently
they have been displaced by some agency subsequent to their original deposit, and have been upheaved in particular portions. The strata, as thus exhibited to view, are inclined at various angles to the horizon. Sometimes the successive layers of deposit are bent and distorted, giving evidence of the force of pressure exerted upon them. In some cases the sedimentary strata are broken through by masses of igneous rock.

5. Order of Succession.—One prime truth, established by the researches of the geologist, is the fact that a certain order of succession is always maintained between particular strata. That is, that certain formations—clays, limestones, or sandstones—are always found to underlie one another, in regular series. Some of the formations may be absent from particular localities, and may be altogether unrepresented over extensive regions, but the existent strata, of whatever they may consist, maintain an invariable order of succession. Chalk, for example, always occupies a higher place in the series than the limestones of the oolitic period, the latter are superior in position to certain descriptions of sandstone, and the last, again, to the carboniferous rocks.

6. Fossiliferous Deposits.—Another great truth is this:—the sedimentary rocks contain, embedded within them, the fossil remains of former vegetable and animal life, and the remains that are proper to each series differ in many essential regards from those of any other series. Each class of rocks, in fact, indicates distinct conditions of life as having existed during the period of its deposit. Thus the fossils found within the clay are different from those of the chalk; the latter, again, from those of the preceding sandstones and limestones, and so on. The lower down in the series we go, the more do these evidences of former periods of life differ from the plants and animals which inhabit the globe in the present day.

7. The transition from the fossil contents of one series of rocks to those of another series is not abrupt. The forms of life which are characteristic of one epoch in the past history of the globe pass by gradual stages into those that are typical of a later period. Certain forms of life appear to die out, and others take their places. The change in this respect, from the fossil contents of the latter to those of the earlier formations, may be likened to that which occurs in the existent vegetation of a mountain-region. As the traveller ascends the lower slopes of the hill-sides, he leaves behind him the character-
istic foliage of the warmer plains—their luxuriant evergreens, rich fruits, and brilliant flowers. A hardier growth comes gradually under view: the laurels and myrtles are succeeded by groves of oak and holly, of beech or elm, while these in turn give place to forests of pine, which cover the mountain-sides at higher elevations. As certain forms of vegetation become fewer in number, and at length disappear, others take their places, and although no precise line of division can be drawn between them, yet the contrast, when the typical aspect of the one region is compared with that of the other, is abundantly obvious. Between the vegetation found at the height of a thousand feet, and that of the mountain's base, there is a wide and manifest distinction, and the forms of life which prevail at an altitude of a thousand feet differ in like manner from those found at double that height.

8. It is thus with the evidence of former life-periods which the solid strata of the globe offer to the observer. The plants and animals that are embedded in the more recent formations—those which are highest in order of position among the sedimentary rocks—present types of life which scarcely differ in some regards from the like forms of life in the present day; while at the same time they offer many examples, both in the vegetable and the animal kingdoms of nature, of forms that have become extinct. Each succeeding series, in the order of descent, exhibits fossil contents which differ more and more widely from the forms that are characteristic of later periods, while each has a typical character of its own.

9. Stratified Rocks.—The classification of stratified rocks adopted by geologists in the present day exhibits the following order of sequence, beginning with those formations which lie uppermost, and proceeding downwards:

1. Post-tertiary or recent accumulations.
2. Tertiary strata.
3. Cretaceous, or Chalk system.
4. Oolitic system.
5. Liassic system.

10. The rocks embraced in this list are termed fossiliferous, since they contain the petrified or fossil remains of plants and animals. It was usual at one time to place at the bottom of the series a system
termed metamorphic, the rocks belonging to which showed certain signs of stratification, but no traces of fossils; and it was supposed that these rocks had undergone some change (metamorphism) subsequent to the period of their deposition. Recent research, however, has proved that metamorphism is confined to no particular system.

The terms bestowed on the above formations are indicative in some instances of the leading mineral characteristic of the rocks which they embrace; in others, of some fact connected with their geographical distribution. Thus, cretaceous implies the prevailing character of the rocks belonging to that series, as developed in the British Islands and elsewhere. The designation of oolitic was given from the fact of some of the limestones which it embraces being composed of small rounded and egg-shaped particles, like theroe of a fish. Triassic denotes the triple group (trias) in which the sandstones and limestones which it contains are commonly found in Germany; and the term Permian has been bestowed upon a lower series of sandstones from their extensive development within the government of Perm, in European Russia. The carboniferous strata are those which contain the extensive coal deposits of our own island, as well as the greater part of the coal of other regions. The term Devonian implies an extensive development of rocks which belong to the older and lower series of red sandstones within the county of Devon. The oldest member of the fossiliferous series—consisting, for the most part, of hardened sandstones and limestones of slaty texture—has been distinguished as Laurentian, from the locality (the basin of the river St. Lawrence), where the strata are most extensively and typically developed.

The epithets of "post-tertiary" and "tertiary" bestowed upon the uppermost members of the series of sedimentary formations bear reference to a classification adopted by the earlier geologists of all stratified rocks into tertiary, secondary, and primary, with reference to their supposed ages. The tertiary rocks were held to comprise all the formations which occupy a place above the chalk; while the strata from the chalk to those of the Triassic (inclusively) were included within the secondary series. The tertiary strata thus comprehend the various clays, marls, and limestones, which are superior in position to the chalk; while the post-tertiary system consists of the various accumulations which are of still more recent origin, and which are coeval with the existence of man.

II. Unstratified Rocks.—The rocks of igneous origin exhibit no stratification, and have no determinate place amongst the various sedimentary deposits. Nor do they exhibit, as a general rule, any traces of organic being. The conditions of their origin—the agency of fire—account for the frequent position of their masses as breaking through and disrupting the sedimentary formations, forming dykes which break the continuity of the latter, or overlying the stratified deposits amongst which they are locally situate.

1 Latin, creta, chalk. 2 Greek, oen, an egg; lithos, a stone. 3 Coal yielding; Latin, carbo, coal, fero, I yield.
12. The entire series of igneous rocks is divided by geologists into three great classes—granitic, trappean, and volcanic. The first embraces granite in its various forms, with the different mineral masses, of crystalline texture, that are found associated with granite. The term trap, applied to the rocks that form the second division, is derived from a Swedish word, trappa, a stair, and was originally bestowed from the terraced or step-like appearance which is often found to belong to districts of ancient volcanic origin. Basalt, and numerous associated rocks of like kind—due to the agency of volcanic fire in former periods—come under the head of trap. There are extensive districts in the British Islands (in Scotland and Ireland) which exhibit trap formations, of which the well-known basaltic columns of the Giant's Causeway, on the coast of Antrim, and Fingal's Cave, in the island of Staffa, offer familiar examples. The third division, which consists of volcanic rocks, embraces the products of modern volcanic eruption, and is applied to the lavas and other matter ejected from the craters of active volcanoes within the historic period.

13. Areas of Deposit.—The geographical area occupied by rocks of igneous origin, though inferior to that of the sedimentary formations, is very considerable; and their importance as agents in modifying the aspect of the Earth's surface renders them of the highest interest to the Physical Geographer. The consideration of modern volcanic action forms the subject of a future chapter. The trap rocks, products of ancient volcanic forces now extinct, impart, in general, a highly picturesque effect to the tracts of country in which they occur, and hence the scenery of such districts often possesses great attractions. Their undulating outline, step-like ascents, abrupt crags and cliffs, and detached conical eminences, present, for the most part, a much greater variety of scenic effect than is produced by those either of granitic or of volcanic origin; and the soil which is formed by their decomposition possesses, in general, great fertility. Granite, on the other hand, often exhibits bare and naked elevations, and the high plateaus which it forms in some districts are generally of monotonous and uninviting aspect, presenting little irregularity of outline, and but scantily covered with soil.

[Granitic rocks form the bases of most of the higher mountain ranges, and their solid masses enter more or less into the composition of most of the elevated or upheaved portions of the crust of the Earth. Granite forms the basis of the entire Alpine region, and appears in all its highest summits. The loftiest]
ridges of the Himalaya system are composed of the same rock. In the great mountain-system of the New World, the Andes, though granite forms the basis of the whole, yet it is seldom met with at the higher elevations of the mountain-region—basalt and other products of later igneous origin crowning, for the most part, the loftiest summits of the chain. The Scandinavian peninsula (Norway and Sweden) is composed principally of granitic rocks—chiefly gneiss and mica-schist—which, with detached masses of granite, form the surface of the bare mountain-plains of Norway. The highland region of Scotland exhibits a like formation.

EXAMINATION QUESTIONS.

1. Of what materials is the Earth's crust composed, and into what two classes are these divided?
2. Explain the meaning of the terms strata, igneous, aqueous, fossil.
3. What facts are observed in reference to the order of succession, in the case of the various rocks?
4. What truth becomes obvious in comparison of the fossil contents of various rocks with one another? To what may the transitions from the fossiliferous contents of one series of strata to those of a succeeding series be likened?
5. Enumerate the ten series of rocks adopted in the geological classification now in usage.
6. What is meant by the term "metamorphic?"
7. Explain the meaning, and give the derivations of, the terms cretaceous, oolitic, triassic, and carboniferous.
8. Whence is the term "Silurian" derived?
9. What is implied by the terms "post-tertiary" and "tertiary?"
10. Into what three classes are the unstratified or igneous rocks divided?
11. Explain the meaning of the word "trap," and mention some examples of rock in the British Islands that come under that designation.
12. What place do granite, and granitic rocks, generally occupy in respect of high mountain-regions?
IV.

THE HIGHLANDS OF THE OLD WORLD.

1. We have already noticed the fact, that the elevated masses of land, in either hemisphere, approach the exterior borders of the continents, presenting a short and rapid declivity towards the nearest sea, and a long slope towards the interior. This longer slope is directed, in the Old and New Worlds alike, towards the Atlantic and Arctic basins. The general direction of the elevated land-masses, however, differs in the case of the eastern from that of the western hemisphere. In the continents of the Old World the general direction of the highlands is east and west: in the continents of the New World, the highlands stretch from north to south. This direction is evidently connected with the general direction of the whole mass of land, and has resulted from the action of those forces by which the continents have assumed their present forms and reliefs. It has been often noticed that in either hemisphere the peninsulas point for the most part to the southward. Both Africa and South America (which are peninsulas in shape, though continental in point of magnitude) exemplify this on a large scale, as Italy, Greece, Hindustan, Korea, Kamtchatka, Florida, and Lower California, do on a smaller proportion. Jutland, in Europe, and Yucatan, in the northern half of the New World, offer the most notable exceptions.

2. Direction of Mountain-chains.—In the Old World, the following are instances of mountain-chains which lie in the general direction of east and west:

<table>
<thead>
<tr>
<th>In Europe</th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td>Pyrenees</td>
<td>France and Spain.</td>
</tr>
<tr>
<td>Sierra Nevada</td>
<td>Spain.</td>
</tr>
<tr>
<td>Sierra Morena</td>
<td>Italy, Switzerland, and Austria.</td>
</tr>
<tr>
<td>Alps</td>
<td>Turkey.</td>
</tr>
<tr>
<td>Balkan Mountains</td>
<td>Russia.</td>
</tr>
<tr>
<td>Caucasus</td>
<td></td>
</tr>
</tbody>
</table>
3. The mountains of Scandinavia, the Apennines, the Ural, the Lebanon ranges, and the Ghauts, are among examples in which the general law is reversed. The cordilleras of the Australian coast assume also a direction of north and south.

4. Plateaux.—It has been already remarked that the plateaux of either continent follow the same general direction as that taken by the mountain-ranges. The latter, in fact, form a portion of the plateau-regions, which they enclose upon every side, and, regarded as affecting climate and other conditions in the economy of the natural world, are altogether subordinate to them in importance. Even the Himalayas, which exhibit in their snow-covered peaks the loftiest elevations on the globe, are but the outer border of the Tibetan plateau; and the traveller who scales them from the southward—passing from the warm plains of the Ganges to the region of eternal snow—finds, when the crest of the mountain-wall is passed, that he is upon the summit of an immense plain. The irregular and peak-crowned rampart through which he has ascended forms the barrier of this vast and elevated region: its highest points rise considerably above the general level of the table-land, and, seen from below, appear to form the connecting links of a continuous mountain-chain. But, viewed as a part of the whole continuous mass of highland, they sink into unimportance as compared with its more solid extent and vastly greater proportions.
5. The principal table-lands in the continents of the Old World are enumerated in the following table:

<table>
<thead>
<tr>
<th></th>
<th>Mean Elevation.</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>In Europe.</strong></td>
<td></td>
</tr>
<tr>
<td>Central Spain</td>
<td>2,000 feet.</td>
</tr>
<tr>
<td>Switzerland and Southern Germany</td>
<td>1,500 feet.</td>
</tr>
<tr>
<td>Norway (southern part of)</td>
<td>4,000 feet.</td>
</tr>
<tr>
<td>Tibet</td>
<td>15,000 feet.</td>
</tr>
<tr>
<td>Mongolia</td>
<td>2,000 to 4,000 ft.</td>
</tr>
<tr>
<td>The Deccan</td>
<td>2,000 to 3,000 ft.</td>
</tr>
<tr>
<td>Afghanistan</td>
<td>6,500 feet.</td>
</tr>
<tr>
<td>Persia</td>
<td>3,000 feet.</td>
</tr>
<tr>
<td>Armenia</td>
<td>6,000 feet.</td>
</tr>
<tr>
<td>Asia Minor</td>
<td>2,000 to 4,000 ft.</td>
</tr>
<tr>
<td>Arabia</td>
<td>3,000 to 4,000 ft.</td>
</tr>
<tr>
<td><strong>In Asia.</strong></td>
<td></td>
</tr>
<tr>
<td>The Sahara, or Desert</td>
<td>1,500 feet.</td>
</tr>
<tr>
<td>Abyssinia</td>
<td>6,000 feet.</td>
</tr>
<tr>
<td>Great African Plateau</td>
<td>3,000 feet.</td>
</tr>
</tbody>
</table>

6. The table-land of Central Spain is by far the most extensive in Europe, and is flanked on the north by the Cantabrian Mountains, on the east by the irregular and broken series of ridges known as the Iberian Mountains, and on the south by the Sierra Morena, while towards the west it gradually slopes between the intervening ranges to the coast plain of Portugal. This plateau is crossed by two well-defined ranges—the Castilian Mountains, and the Mountains of Toledo—both of which are continued into Portugal. The three valleys thus formed are drained by the Douro, Tagus, and Guadiana respectively. The whole of this region is void and treeless, and is exposed to extremes of heat and cold, thus presenting a striking contrast to the fertile coast plains which encircle it. The high grounds of Switzerland are less defined, and are broken up by far loftier ranges than those of Spain, while those of Southern Germany are of very moderate elevation. In the southern portion of Norway, also, the various ranges present the appearance, not so much of definite ridges, as a closely-connected series of table-lands.

7. But the plateaux of Europe sink into insignificance when compared with the immensely greater and far loftier table-lands of the Asiatic continent, which occupy two-fifths of its entire extent. In fact, the Asiatic table-lands constitute an almost continuous belt 6,000 miles in length, from the shores of the Mediterranean north-east towards the Sea of Okhotsk, and comprise an area nearly twice the total area of the European continent. This immense belt of high ground,

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1 The so-called "Carpathian-Uralian Plateau," between the Carpathians and the Urals, has a much larger area than the Spanish plateau, but most geographers regard it not so much as a plateau, but rather as a slightly elevated continuation of the great Central Plain of Europe.

2 The Castilian Mountains are continued through Portugal as the Sierra d'Estrella, and the Mountains of Toledo as the Sierra Guadaloupe.
although continuous as regards absolute elevation, is nevertheless naturally divisible into several sections. Commencing in the west, we have the Nejd or interior plateau of Arabia, which consists of a series of high and desert plains, destitute of perennial streams, but generally adapted for pasturage. The Arabian highland is crossed by several ranges of no great height, and is bounded on all sides but the north by a series of generally moderate elevations, between which and the sea is the low and narrow plain known as the Tehama. The interior of Asia Minor is also a plateau, with an average elevation of 3,000 feet. On the north and south this plateau descends by successive terraces to the shores of the Black and Mediterranean Sea. On the west it gradually declines towards the waters of the Archipelago. The southern border of the plateau is formed by the chain of Mount Taurus, the passes through which consist of deep and rugged defiles. The highlands of Asia Minor proper are continued east into the plateau of Armenia, which rises abruptly from the plains of Al-jezireh and Irak-Arabi, through which the Euphrates and Tigris flow. The Armenian plateau is bounded on the north by the chain of the Caucasus, and with it forms the highland that intervene between the Black Sea and the depressed basin of the Caspian. Intimately connected with this upland region is the Plateau of Iran, in Persia, which is bordered on three sides—the north, west, and south—by mountain-chains, which divide it from the low country along the Caspian Sea, the Persian Gulf, and the banks of the Tigris. This plateau is generally arid, especially in the north, where it forms the basin-like expanse of the "Great Salt Desert." The elevated regions of Afghanistan and Beluchistan may also be regarded as merely a prolongation of the Iranian plateau, which thus extends from the Tigris to the Indus.

8. The highlands of Afghanistan are connected by the lofty range of the Hindu-Kush with the central table-land of Asia—the Pamir Plateau—the central knot, whence radiate the four great mountain-chains of the continent—the Thian Shan, Kuen Lun, the Himalaya, and the Hindu-Kush. The average elevation of this plateau is probably not far short of 15,000 feet, which exceeds the average height of the loftiest mountains in Europe. The great ranges which extend from this plateau north-east and south-east enclose the most extensive and elevated table-land on the globe. From the Himalaya on the south to the Altai on the north, and from the Pamir on the west to the Yungling, Inshan, and Khin-ghan ranges on the east, is one vast upland—ranging in height from 4,000 feet in Mongolia, to 17,000 feet in Tibet—forming the loftiest inhabited region in the world. This vast tract is naturally divisible into four regions—the Plateau of Tibet, embayed between the Himalaya, the Karakoram, and the Kuen Lun ranges—the Plateau of Eastern Turkestan, similarly embayed between the Thian Shan and the Kuen Lun, gradually sloping on the east into the great sandy desert of Gobi or Shamo, which again rises into the Plateau of Mongolia, which is flanked on the north by the Altai mountains, and on the east by the Khin-ghan range. South of the Himalayas are the minor but still considerable table-lands of Malwa and the Deccan—the former north and the latter south of the Vindhya Mountains. The Deccan occupies nearly the whole of peninsular India, and is bounded on the east and west by the Ghauts, between which and the sea is a narrow but fertile plain.
9. The characteristic narrow coast plains bounded by ranges buttressing the interior plateau-lands of Arabia, have their counterpart on a far larger scale on the adjoining continent of Africa. All the great mountain-chains of Africa are in close proximity to the coast, and an examination of a good relief map of Africa will show that the interior districts which they enclose have nearly everywhere an elevation which entitles them to be regarded as forming a series of more or less elevated table-lands. Commencing on the north, we have the Sahara, which has for the most part an elevation of from 1,500 to 3,000 feet, and which includes the minor plateau of Ahir or Asben. Between the Upper Nile and the Red Sea is the lofty plateau of Abyssinia, which rises abruptly from the low coast plains of the Danakil country to a height of 7,000 or 8,000 feet. The whole interior south of the Sahara may be regarded as forming a series of plateaux, with an average elevation of not less than 3,000 feet, and flanked on either side by mountain-chains, lying generally adjacent to and trending parallel with the coast—moderately elevated on the west, but rising on the east occasionally far above the snow-line. It is on this vast, and on the whole fertile and habitable upland, that the great lakes of Central Africa are situated—the Victoria Nyanza at an elevation of 3,800 feet, and Lake Tanganyika at a height of 3,700 feet; and hence also the three great rivers of Africa radiate—the Nile north, the Congo west, and the Zambesi east. Towards the extreme south of the continent, the country descends stage by stage to the coast, hence the peculiar terraciform aspect of the maritime districts of Natal and the Cape Colony.

10. Deserts.—The highland regions of the Old World coincide in great measure with the arid tracts of land which stretch through the African and Asiatic continents in the general direction of east and west, forming a vast belt of desert. Looking at the map, and commencing with the plateaux of interior Asia, we observe in succession, proceeding from east to west—the Gobi, and adjacent deserts of Turkestan; the Great Indian Desert (to the eastward of the Indus); the deserts of Beluchistan and Seistan; the Great Salt Desert of Persia; the Syrian and Arabian Deserts; the Egyptian and Nubian Deserts, between the Red Sea and the Nile; and, to the west of the last-named river, the vast expanse of the African Sahara, stretching to the very edge of the Atlantic Ocean. This immense range of country, condemned to comparative aridity, and, as a consequence, thinly inhabited, constitutes, in all physical regards, one of the most remarkable portions of the earth. Though comprehended, in a general sense, under the term "desert," it must not be supposed that these wide-spreading regions exhibit uniformity of physical aspect.

11. The Gobi is a region of grassy plains, alternating in some instances with tracts of gravelly or sandy surface—whence the Chinese appellation of Shamo (i.e.
Sea of Sand) given to portions of it. But the Mongol shepherds pasture their herds over by far the larger portion of the vast plains which the Gobi embraces.

12. The Deserts of Turkestan are of a formidable character. Upon either side of the Jaxartes stretch the extensive sandy wastes known respectively as "Kizil-kum," and "Kara-kum," where the traveller is exposed to the occasional hot blast of the tebbâd—terrible as the simoom of the African wilderness.

13. The Indian Desert—an expanse of not less than 150,000 square miles—is not barren throughout. In its worst portions the desert exhibits a series of sand-hills, divided by valleys in which scatty crops of grain may be raised during and immediately after the rainy season. But the rains are often slight and irregular in their recurrence, and when the intense heat of summer has burnt up the scatty vegetation of shrubs and grass, which forms a covering to the hillocks, the fine sand is blown about by the wind, and hills and valleys alternately shift their places. The whole region then becomes an uninhabitable waste, which only the camel can cross with safety.

14. The Great Salt Desert of Persia is distinguished, as its name implies, by the saline efflorescence with which its surface is covered, and which causes the ground to sparkle in the distance under the rays of the sun. The Mesopotamian and Syrian Deserts are barren only during the season of summer heat, when the surface of the ground becomes parched, and clouds of dust, raised in whirlwinds from the arid soil, fill the air; at other seasons, when the thirsty soil is moistened by the rains of winter and early spring, they are covered with a carpet of verdure, and are bright with the hues of a countless variety of wild flowers. This is the brief "glory of the wilderness," destined to pass away with the returning heat of the summer sun.

15. The Syrian Desert passes to the southward into the arid regions which fill the greater part of the interior of the Arabian peninsula. The north-western corner of Arabia is a wilderness of naked rocks and barren mountain-chains, divided by the deep (and, during eight months of the year, dry) beds of water-courses—the "wadies" of Arabian geography. This is the Arabia Petrea of modern geography. But a large portion of interior Arabia, especially towards the south, consists of high and nearly waterless plains, with, in many places, immense tracts of loose drift-sand. The sand constantly changes its position, and renders extensive districts uninhabitable. The appellation of "Robâ-el-Khaly"—empty (or deserted) abode—given, as Burckhardt tells us, to the southern interior of the peninsula, supplies a striking indication of its characteristics. But the mountain-belt which borders Arabia on three sides includes watered and fertile valleys, in which the moistened soil yields corn and fruit in abundance.

16. The African Desert—or "Sahara"—stretches through 3,000 miles in the direction of east and west, and from eight hundred to upwards of a thousand miles in that of north and south. But the whole of this immense area is not equally arid. About the meridian of 14° east it is divided by the broad valley

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*That is, the Rocky Arabia—Greek, petra, a rock.*
of Fezzan—a region partially redeemed from the prevailing sterility. To the eastward of Fezzan, the desert is less generally sterile than in its westerly division, and the "oases" which impart variety to its surface are of more frequent occurrence. Neither here nor in the western portion of the Sahara, however, does the desert consist of level plains, as is often supposed. High chains of naked rocks cross its surface in some places, and the traveller has to shape his course through their narrow and winding defiles. In other places the shifting sand, of which entire hills are composed, obliterates all traces of a path, and compels the caravan which crosses the wilderness to depend for guidance upon observation of the sun or stars. The atmosphere over the more parched and arid regions presents at times the appearance of a red vapour, the heat of which, augmented by the burning wind known as the simoom, (or samiel), is sometimes so great as to dry up the water carried for the use of the caravan, which, in such cases, is exposed to the imminent danger of perishing from thirst.

[The oasis^1 of the desert is either the bed of a water-course, where the rains of winter are collected into a few hollows in the ground, or the depressed region surrounding a perennial spring, the water of which nourishes a verdure that becomes the more strikingly attractive from its contrast with the surrounding waste. The date-palm is everywhere the characteristic of the oasis, in so far as vegetation is concerned, and thrives luxuriantly wherever water is found. Elsewhere, the only vegetation of the wilderness consists of a few thorny shrubs and briars, intermixed with an occasional and scanty covering of grass. The camel alone traverses with comparative facility the more arid portions of the Sahara, which, without its aid, would be to mankind an impassable barrier.]

17. Mountains.—Mountains exhibit every variety of form, and impart corresponding diversity of contour to the valleys which they enclose, or the lower heights which spread around their base. It is this variety, combined with other features of the landscape, which lends their well-known charm to the scenic aspects of mountain-lands. Some mountains rise with a steep ascent, their sides exhibiting bold escarpments, while others display gentler slopes, through which the valley passes gradually into the hill-side, and the hill into the mountain. The summits exhibit, in some cases, a rugged and precipitous crest, upon which are aggregated huge masses of rock, grouped wildly together; in others, they display a rounded or dome-shaped elevation, or (as in volcanic regions) present the figure

^1 From a Coptic term, signifying a "resting-place." The unfailing spring of water points out the natural resting-place of the traveller through the wilderness, and the position of the wells hence determines the direction of the routes which cross it. The Greeks likened the oasis, with its attractive verdure, surrounded by the wilderness, to an island in the midst of an ocean.
of a cone. In numerous instances, the highest portion of the mountain exhibits a flat plain, or "table." The Table Mountain, at the Cape of Good Hope, is a well-known example. Mount Tabor, in the Holy Land, is an instance of like kind, as also are many of the hill-forts of the Deccan, so famous in the records of Indian warfare. In the case of these latter, the flat-topped hills, often crowned with solid masonry which might bid defiance to the strength of any other than European arms, rise steeply above the plains of Central India, their perpendicular walls of rock presenting examples of amazing natural strength.

18. The ravines, or defiles, which penetrate mountain-regions, and the high passes which rise with gradual ascent to the crest of the mountain-chain, and traverse its lofty elevations, display every possible variety of contour and aspect. The passes which traverse the Himalaya and the Andes rise, in some instances, to the surprising elevation of fifteen thousand feet and upwards. The passes of the Alps reach more than eleven thousand, and those of the Pyrenees nearly eight thousand feet, above the sea. In Norway, the summit of the mountain-region is a broad plain, or "field," over which the roads of that rugged land pass at elevations of four thousand feet.

19. Much importance attaches, historically, as well as commercially, to mountain-passes—the pylce, or gates (as they were termed by the ancients), through which extensive regions are alone accessible. The road of the Simplon, constructed under the orders of Napoleon, first facilitated intercourse between the dwellers upon opposite sides of the Alps. The rugged defiles which traverse the chains of the Taurus, in the southern part of the Lesser Asia, constitute the approach to Syria, and have been marked by the footsteps of invading armies, in the periods of ancient and modern history alike. In southern India, the high range of the Eastern Ghauts would forbid communication between the interior and the maritime tract which borders the Bay of Bengal, were it not for the wild passes, which, "worn by mountain torrents, and dark with jungle," lead from the table-land of the Mysore to the plains of the Carnatic. Nor does it require any considerable altitude to give importance, politically as well as in other regards, to the variety of external feature which hill-regions, and the roads which traverse them, exhibit. The moderate elevations of the Argonne sufficed to check the advance of an invading army, and proved the safeguard of revolutionary France
in 1792. Every campaign, alike in modern and in ancient warfare, furnishes instances of the importance which attaches to such features of natural scenery as are exhibited by hilly lands, even when their altitude is insignificant as compared with that of the great mountain ranges of either continent.

[The varieties of aspect above referred to are intimately connected with geological structure. Every kind of rock-formation—granite, trap, mountain-limestone, chalk, or alluvial deposit—has its characteristic external form, and imparts its distinguishing quality to the soil by which its strata are superficially covered. The rounded, swelling, and grass-covered hills, or downs, which belong to the chalk-region of south-eastern England, are a familiar example of this. The deep glens, abrupt precipices, and overhanging hill-sides, found within tracts which are composed of the older members of the stratified rock-formations—as in the mountain districts of Cumberland, Wales, and the Highlands of Scotland—are an instance of an opposite kind. Gentle slopes, hills of more rounded form, and valleys of softer aspect and more extended limits, watered by streams which differ altogether in character from the mountain-torrents of bolder regions, distinguish those portions of England which are traversed by the intermediate members of the sedimentary formations,—the various sandstones and limestones lower in order of position than the chalk. The limestone caverns of Derbyshire belong to the period of carboniferous deposit, and find an equivalent in the caves of Adelsberg, amongst the Illyrian Alps, as well as in the similar formations of other regions.]

20. The term "mountain" is generally applied to elevations above 1,000 feet, and may denote isolated cones, or a series of connected elevations. The former are nearly always volcanoes, or of volcanic origin, and are consequently of comparatively rare occurrence; the latter forms by far the most common aspect of elevated ground. Geographers generally designate a series of connected elevations, if in the same line, a mountain-range—if irregularly arranged, but still near each other, a mountain-group. A series of mountain-ranges generally parallel to one another forms a mountain-chain, and a series of ranges and groups of mountains having the same general direction or position, forms a mountain-system. But it must be borne in mind that, while isolated mountains may very properly be described separately, a series of elevations can only be treated of in connection with each other, and with the "area of elevation" of which they form an integral part. So that, although it is, for the sake of clearness, absolutely necessary in a work of this kind to describe the table-lands and mountain-chains separately, still the student should combine the information thus given, for it is only

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1 Some geographers restrict the term "mountain" to elevations above 2,000 feet, all under this height being called "hills."
by studying the mountain-ranges of the world in connection with the plateaux from which they rise, that a true idea of their character can be realised. Mountain-ranges are not, therefore, generally speaking, mere ridges; and definite mountain-chains, in the common acceptance of the term, have no existence. The principal table-lands of the Old World have been already briefly noticed; we pass on, therefore, to point out the principal features of the great mountain-ranges which enclose or traverse them.

[In connection with this intimate and indissoluble relation between mountain-ranges and their adjoining highlands, it is worthy of note that the line of greatest elevation in High Asia—that is, the Himalayas and connecting ranges—trend from W.N.W. to E.S.E., while the table-land or plateau itself trends in a contrary direction, that is, from W.S.W. to E.N.E. From this it is evident that the so-called mountains were upheaved subsequent to the table-land; or, in other words, that the table-land of Central Asia is, geologically considered, older than the ranges which buttress or traverse it.]

21. Mountain-Systems of the Old World.—Looking at the Old World as a whole, we find that it has in reality but one great mountain system—to which the other highlands on either side may be considered as outliers. The vast system we refer to extends in an almost continuous belt from Cape Roca, the most westerly point of Europe, to East Cape in Siberia, the most easterly point of the Asiatic continent—a distance of not less than 9000 miles. The more conspicuous sections of this vast highland belt, proceeding from west to east, are the Spanish Mountains, Pyrenees, Alps, Balkans, Taurus and Anti-Taurus, Caspian Mountains, Hindu Kush, Himalaya, Kuen Lun, Thian Shan, Altai, Yablonoi, and the Aldan or Stanovoi Mountains.

[These successive sections do not, however, by any means constitute a "single, well-defined, continuous chain throughout," but form 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 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 being distinctly indicated. On the contrary, diversification 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 from the Pyrenees to the great system of Asiatic mountains, which enclose the plateau of Tibet."]

1 As, for instance, the Himalaya and the Kuen Lun, neither of whom have, strictly speaking, any definite special existence apart from the elevated mass of Tibet. "I no longer," says Dr. Hooker, "consider the Himalayas as a continuous snowy chain of mountains, but as the snowed spurs of far higher unsnowed land behind, which higher land is protected from the snow by the peaks on the spurs that run south from it."

2 Sir John Herschel.
22. **Classification of Mountain-Systems.**—But in order to form an accurate idea of this vast system of elevations as a whole, it is necessary to study its component parts separately; hence the necessity for a logical, and, as far as possible, natural, subdivision. Thus the portion of the main belt within Europe is naturally divisible into two great sections, the *Iberian System*, comprising the various ranges of the Spanish peninsula, together with the Pyrenees; and the *Alpine System*, embracing the Alps proper, and its prolongations—the Apennines, the Balkans, and the Hercynian and Carpathian Mountains. But besides these we have three other well-defined subordinate systems, viz., the *British System*, in the British Islands; the *Scandinavian System*, in Norway and Sweden; and the *Uralian System*, consisting of the chain so called. Two other minor groups may also be noticed—the insular *Sardo-Corsican System*, in the islands of Sardinia and Corsica, and the inland *Sarmatian System* in Russia.

23. In Asia, the main belt may be considered in four sections—the *Western System*, embracing the various ranges of Asia Minor, Armenia, Persia, and Afghanistan; the *Central System*, comprising the great ranges which radiate from the central knot of the Pamir—viz., the Hindu Kush, Himalaya, Kuen Lun, Thian Shan, and Altai Mountains; the *Eastern System*, comprising the whole of the ranges of Eastern Siberia and China, the Stanovoi, Yablonoi, Khinghan, Inshan, Yungling, Peling, and Nanling ranges; and in connection with these three systems, the sub-systems of the three great peninsulas of Southern Asia—Arabia, Peninsular India, and Further India.

24. The various mountain ranges of Africa may be classed under four systems—the *Northern*, including the Atlas range; the *Western*, embracing the Kong Mountains, the Cameroons, Sierra Complida, and other ranges that skirt the western coast; the *Southern*, including the various ranges of the Cape Colony; and the *Eastern*, embracing the Drakenberg, Lupata, and other ranges which mark the eastern limit of the great Central African Plateau, and also the Abyssinian highlands. Besides these coast ranges, it will also be necessary to notice the principal interior ranges discovered within recent years.

25. It may also be advisable to append to this section a short notice of the chief Australian and Polynesian elevations, reserving for the next chapter only those ranges which are included within the limits of the American continent.
26. The Mountain-Systems of Europe.—The mountain systems of Europe have already been enumerated. The following notes on each system are necessarily brief, but sufficient information is given to enable the student to form a tolerably clear idea of its leading features. It may, perhaps, be advisable to commence with the two main systems—the Iberian and Alpine—and then note the outlying Sardo-Corsican, British, Scandinavian, Sarmatian, and Uralian Systems.

Iberian System.

| Sierra Nevada, Mulahaçen | 11,660 |
| Sierra Morena, Aracena | 5,105 |
| Sierra Monchique, Foia | 2,963 |
| Mts. of Toledo, S. Guadalupe | 5,110 |
| Sierra d'Ossa | 2,139 |

Castilian Mountains, S. de Gredos | 8,690 |
Sierra d'Estrella | 6,540 |
Cantabrian Mts., Cerredo | 8,784 |
Pyrenees, Maladetta | 11,168 |

27. Iberian System.—This system includes the various ranges which traverse the Spanish peninsula, together with the lofty barrier range of the Pyrenees. The characteristic features in the relief of the Spanish peninsula have been already observed—the central plateau buttressed on three sides, the north, east, and south, by comparatively lofty ranges, and traversed by two other ranges, the whole of which (with the exception of the irregular and broken eastern range) have an east-to-west direction, gradually curving south as they approach the shores of the Atlantic.

Several of the summits of the Sierra Nevada which extend along the south coast, rise above the snow-line (which there attains an elevation of about 11,000 feet.) The highest point, Mulahaçen, is also the culminating point of the peninsula, exceeding by about 500 feet the most elevated peak of the Pyrenees. The famous plain of Andalusia intervenes between this range and the Sierra Morena, the southern buttress of the Spanish table-land. Further north are the parallel chains of the Mountains of Toledo, the Castilian Mountains, and lastly, the Cantabrian Mountains. The latter rise steeply from the shores of the Bay of Biscay, and form the northern limit of the central table-land. This range merges on the east into the great barrier range of the Pyrenees, which extends across the isthmus which unites the Spanish peninsula to the mainland of Europe. The average elevation of the Pyrenees is probably not far short of 8,000 feet, but upwards of twenty peaks exceed 10,000 feet in height. The snow-line descends nearly to the average elevation of the range, hence all its loftier summits are covered with perpetual snow, and its higher valleys are blocked by

1 Of the names bracketed in the above table, the first is that of the range within Spain, and the second, the continuation of the same range in Portugal. Thus the Sierra Morena in Spain, is prolonged through Portugal as the Sierra Monchique, and so on.
glaciers of considerable size. The southern slope of the Pyrenees is steep and rugged; on the north the descent is much more gradual. Of the numerous passes, only four are practicable for carriages.

28. The Pyrenees slope on the north into a narrow plain, beyond which rises the moderately elevated chain of the Cevennes, which forms the boundary between the valley of the Lower Rhone and that of the Upper Loire. A north-westerly spur of the Cevennes forms the Mountains of Forez, west of which, within the former province of Auvergne, is a remarkable group of hills of volcanic origin. The numerous crones and craters, and vast deposits of ashes and lava, evidently point to a period of most intense igneous activity in this region. Further north, the belt of highland is prolonged by the Côte d'Or Mountains, the Plateau of Langres, and the Vosges. To the eastward of the first-named group is the forest covered chain of Mount Jura, which rises abruptly from the western shores of Lake Geneva and that of Neuchatel. The northern portion of the Vosges is within Germany—the rest is in France. Mount Jura forms the frontier line between France and Switzerland.

29. The Alpine System.—The Alpine system embraces not only the Alps proper, but also the outlying ranges of the Hercynian Mountains, north, the Carpathians and the Balkans, east,—and the Apennines, south of the main section of the system.

The term Alps is usually restricted to those lofty ranges which extend in a semicircular direction round the head of the Italian peninsula, together with

1 It was on the Puy de Dôme, in the mountains of Auvergne, that the decrease of barometric pressure consequent on increased elevation was first observed by Pascal in the middle of the 17th century.

2 This range, and indeed the whole of the mountains of eastern France, are by some geographers regarded as forming part of the "Alpine system," but we prefer to restrict the latter term to those elevations that lie east of the Lower Rhone, the Aar, and the Rhine.
those which ramify through Switzerland and south-western Austria. The system of the Alps proper is not only the most magnificent, but also the most complicated of European mountain-systems, and the continuous, and at first sight bewildering, succession of lofty ranges and groups extending from the shores of the Gulf of Genoa to the banks of the Danube, requires careful examination and analysis. The component ranges of Alps radiate from the central ridge of the St. Gothard. From this point the Valais Alps extend south-west, and is prolonged south as the Graian, Cottian, and Maritime Alps, and still further south, through the entire length of the peninsula, as the Apennines. Hence, also, the Bernese Alps extend west-south-west between the basins of the Upper Rhone and the Aar—while from the same point the Vierswaldstätter Alps run north to Lake Lucerne, between the Aar and the Reuss; and the Swiss Alps, or Todi range, north-west, between the Reuss and the Vorder Rhine—the main ridge abutting on the left bank of the latter river. East of St. Gothard, the various ranges that traverse the Swiss cantons of Ticino and the Grisons, and the Austrian province of the Tyrol, may be grouped together as the Rhaetian Alps, or the eastern limit of which is marked by the Brenner Pass. Thence the system bifurcates one branch, the Noric Alps and its prolongation extending north-east to the neighbourhood of Vienna and Presburg, near the latter of which commences the range of the Carpathians—the other branch trending south-east under the names of the Carnic, Julian, and Dinaric Alps, at a short distance from, and nearly parallel to, the Adriatic Sea. The last mentioned section—the Dinaric Alps—joins the Balkan system in the lofty group of the Sharra Tagh, whence also extends the chain of the Pindus.

30. The culminating points of the various sections of the Alps are shown in the above table, and need not therefore be recapitulated here. We may, however, note that the altitude of the highest summit—Mont Blanc, situated on the frontier of Savoy and Piedmont, and near the Swiss border—is scarcely half that of the culminating summits of the Himalaya. But while the elevation of the snow-line on the Himalaya exceeds the highest point in the Alpine system, the limit of perpetual snow in the Alps proper descends to 8,000 feet, so that all its higher portions are crowned by snow-covered peaks.

[As regards variety and magnificence of scenery, the Alps are probably inferior to no other mountain-system on the globe, and they are superior to most others in these regards. The lakes that lie embosomed within their valleys, the foaming torrents and waterfalls that descend their steep and wooded sides, and, more than all, the glaciers that originate within the snow-region, and descend to the plains beneath, lend to the great mountain-system of the European continent scenic charms of the highest order. It is upon the northern face of the Alps that the larger glaciers are found: those on the Italian face of the mountain-crest are few in number, and of smaller proportions. Regarded as a whole, the Alps, although modelled on a scale of magnitude much below the great ranges of the Asiatic continent, yet assume an aspect of superior importance when regarded in their influences on the destinies of the human race. During a long succession of ages, this magnificent chain around the head of the}
Italian peninsula—protecting its rich plains from the less genial influences of a northerly sky—parted two worlds from one another. The fairest buds of civilisation had already opened under the Grecian and Hesperian skies, while scattered tribes of barbarians were yet wandering in the forests of the north. "How different," exclaims Heeren, "would have been the whole history of Europe, had the wall of the Alps, instead of being nearer the Mediterranean, been removed to the shores of the North Sea!" This boundary, it is true, is of less moment in our time, when the enterprising spirit of the European has constructed splendid roads across these lofty chains, and pierced through their mightiest masses, as it has found a path over the ocean; but it was of decisive importance for the age of antiquity. The north and the south were then physically, morally, and politically divided, and the mountain-chain long remained the bulwark of the one against the other. Cæsar planted the Roman eagles upon the banks of the Rhine and beside the waters of the German Ocean; but under the later rulers of Rome, the Alps again became the virtual limit of the imperial power, and their natural strength served to delay for a time the overthrow of the declining empire at the hands of its rude invaders.1

31. Northward of the Higher Alps are the minor ranges and highlands of Germany, which are directly connected with the main chain by the Bavarian Alps and Plateau. The so-called Bavarian Alps are but the northerly ramifications of the Rhaetian Alps, and mark the southern limit of the series of undulations collectively known as the Bavarian Plateau, from the north-west corner of which rises the remarkable mountain mass of the Fichtel-Gebirge—the central knot whence radiate the chief ranges of Germany. Hence extend the Franconian Jura and the Swabian Alps south-west to the Schwarzwald, or Black Forest Range, between the valleys of the Rhine and its tributary the Neckar. From this point also the Frankenwald and the Thuringerwald extend north-west—the Erz Gebirge, north-east—and the Bohmerwald, south-east. West of the Thuringerwald, and between it and the Rhine valley, are the Rhon Gebirge, the Vogelsberg, the Taunus, and Westerwald—and to the north, the Teutoburgerwald, and the Harz Mountains. To the east of the Bavarian Plateau is the slightly less elevated plain of Bohemia, completely enclosed by the Bohmerwald, the Erz Gebirge, the Riesen Gebirge, and the Marische Gebirge. The Riesen Gebirge is prolonged south-east as the Sudeten Gebirge, the offshoots of which unite with the Carpathians.

32. The rugged and richly metalliferous range of the Carpathians forms nearly a semicircle, 900 miles in length, enclosing the fertile and highly-productive plain of Hungary. From the Danube, near Presburg, the range extends north-east as the Little Carpathians, and then east and south-east as the

1 The principal passes over the Alps are—the Pass of Mont Cenis (6,772 feet), fifteen miles west of which is the famous Mont Cenis Railway Tunnel—the Little St. Bernard (7,192 feet), across the Graian Alps—the Great St. Bernard (8,131 feet), across the Pennine Alps—the Simplon (6,923 feet), traversed by Napoleon's splendid military road—the St. Gotthard (6,936 feet), across the Lepontine Alps (the Great St. Gotthard Railway Tunnel, recently completed, pierces this ridge)—the Splügen (6,946 feet), from Coire to Como—the Stelvio (9,172 feet), the loftiest carriage road in Europe—and the Brenner (4,660 feet), traversed by a road and a railway.
The Carpathians proper; curving west at 26° W. long. as the Southern Carpathians, finally terminating at the "Iron Gate" of the Danube, near Orsova. The Danube thus separates the Carpathians from the north-eastern offsets of the Noric Alps at Presburg, and from the north-westerly spur of the Balkans at Orsova. The Carpathians consist rather of "mountain groups connected by elevated plains" than a single chain. The average width of the range is not less than 100 miles, except in the south-east, where the numerous spurs that traverse the Transylvanian province result in a belt of high ground, at least 200 miles across. It is in the Transylvanian Alps that the most elevated summits of the Carpathian system occur—the highest of these, however, only exceeds by 1,400 feet the culminating point of the remarkable Tatra group in the north-west of the Carpathians proper. The slope of the Carpathians is inwards, that is, towards the Hungarian plain—the counter slope towards Roumania and Galicia is for the most part extremely steep.

The Alpine System—II. Subordinate Ranges.

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<th>Feet.</th>
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<tbody>
<tr>
<td>Bavarian Alps, Zugspitz ........9,716</td>
<td>Sharrag Dagh, Balasanitza ...7,462</td>
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<tr>
<td>Schwarzwald, Feldburg ........4,901</td>
<td>The Balkans, Koja ........5,904</td>
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<tr>
<td>Böbmerwald, Arber ........4,783</td>
<td>Despoto Dagh, Rilo Dagh ...9,018</td>
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<tr>
<td>Erz Gebirge, Keilberg ........4,182</td>
<td>Mount Pindus, Karavi ...6,970</td>
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<tr>
<td>Riesen Gebirge, Schneckkopf ...5,186</td>
<td>Mountains of Greece, Liakura 8,259</td>
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<tr>
<td>Harz Mountains ................</td>
<td>The Apennines, Monte Corno ..........9,521</td>
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<tr>
<td>The Carpathians, Somnitz ...8,779</td>
<td>Mountains of Sicily, Etna ...10,874</td>
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<tr>
<td>Southern Carpathians, Dzurul ...7,574</td>
<td>Sardinian Mountains, Gennargentu ...6,132</td>
</tr>
<tr>
<td>Transylvanian Alps, Ruska Poyana ...9,912</td>
<td>Corsican Mountains, Monte Rotondo ....9,069</td>
</tr>
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33. We have already (Art. 29) traced the course of the most easterly offset of the Alps proper—the Dinaric Alps—to its junction with the lofty group of the Sharrag Dagh, which may be regarded as the centre whence the various ranges of the Balkan peninsula diverge east, west, and south. Eastwards the main chain of the Balkans extends for over 300 miles, terminating at Cape Eminch, on the Euxine coast. The principal offsets from the main range are the North Balkans, trending north to the "Iron Gate" of the Danube; the Little Balkans, extending south-east to the shores of the Bosphorus; and, further west, the Despoto Dagh, or Rhodope Mountains, running in the same direction to the coasts of the Egean. But the "backbone of the Balkan peninsula" is the chain of Mount Pindus, which stretches from the Sharrag Dagh to the Isthmus of Corinth, south of which it is prolonged in the Morean highlands, finally terminating in Cape Matapan, the most southerly point of the European continent. The lateral coast-ranges are far higher than the main chain of the Pindus, which rises, however, in Northern Greece, in the lofty peaks of Kiona and Liakura, to upwards of 8,000 feet in height. The coast-ranges culminate in the famous Mount Lacha, Kisovo, and Plessidi, (the Olympus, Ossa, and Pelion of the ancients).
34. The mountain-system of the adjoining peninsula of Italy consists of one main range, extending from the head of the Gulf of Genoa to Cape Spartivento, and several unimportant lateral ranges. The main range, known as the Apennines, is a direct prolongation of the Maritime Alps—the dividing point being the Col di Tende. The Apennines are not only much less elevated than the Alps, but are also almost entirely devoid of the rugged character of the Alpine ranges—hence the scenery is generally tame and monotonous. The lateral ranges on the west are parallel to the main chain, while those on the east are at right angles to it. West of the Southern Apennines is a chain of isolated peaks, of volcanic origin—among which towers the active volcano of Vesuvius. The volcanic chain is evidently continued in the Lipari Islands and Mount Etna. Of the Sicilian Mountains, the main range, extending from Cape Faro to Cape Boeo, is evidently a continuation of the Apennines. South of this range, and entirely detached from it, rises the gigantic cone of Mount Etna—the most elevated volcano in Europe.

35. The Sardo-Corsican System includes the various ranges which extend throughout the entire length of the islands of Sardinia and Corsica, from Cape Spartivento to Cape Corso. This system, which, geologically considered, is a mere "outlier" of the Alpine System, culminates in Monte Rotondo, in Corsica, and Monti de Gennargentu in Sardinia.

<table>
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<tr>
<th>The Scandinavian System.</th>
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<tr>
<td>Kiolen Mountains, Sulitelma</td>
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<tr>
<td>Dovrefield, Snehatten</td>
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<td>Ymesfield, Galbhøppigen</td>
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<td>Sognefield, Shagstlostind</td>
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<td>Hardangerfield, Jöklen</td>
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<td>Gaustafeld, Gausta</td>
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36. The Scandinavian System.—This system embraces the whole of the mountains of Norway and Sweden, extending from Cape Nordkyn to the Naze.

These mountains, says Forbes, "have been very erroneously supposed by map-makers to form a continued ridge serpenting through the country, though preserving a general parallelism to the coast;" but, adds the same writer, they "do not constitute either unbroken chains rising from the low grounds and forming a ridge, nor are they a series of distinct detached elevations, but, in the southern division of the country especially, they form plateaux or table-lands of great breadth, and generally more or less connected together, though occasionally separated by deep but always narrow valleys. These wonderful expanses of mountains are often so level, that, upon what may almost be called their summits, a coach and four might be driven along or across them for many miles, did roads exist; and across them the eye wanders for immense distances, overlooking entirely the valleys, which are concealed by their narrowness, and interrupted only by undulations of ground, or by small mountains, which rise here and there with comparatively little picturesque effect above the general level." These table-topped mountains are the Fields or Fjelds, and are locally distinguished as the Kiolen Mountains in the north, the Dovrefield in the
centre, and the Hardangerfield, &c., in the south. (These divisions, with the culminating points in each, are shown in the table, page 44). The western or Norwegian side of these mountains exhibits a vast mountain-wall rising precipitously above the adjacent ocean, and penetrated by innumerable fjords, while the other side has a gradual inclination towards the shores of the Baltic. The valleys in this mountain region are vast rents or chasms, and are altogether unlike the valleys of other lands. The snow-line descends from an elevation of four or five thousand feet in the southern portion of the peninsula, to only a few hundred feet in the neighbourhood of the North Cape. There are glaciers of considerable extent in many of the loftier ravines.

The British System.

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<thead>
<tr>
<th>Scotland</th>
<th>Feet.</th>
</tr>
</thead>
<tbody>
<tr>
<td>Northern Highlands, Ben Atto</td>
<td>4,000</td>
</tr>
<tr>
<td>Grampians, Ben Nevis</td>
<td>4,406</td>
</tr>
<tr>
<td>Southern Highlands, Broadlow</td>
<td>2,700</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>England and Wales</th>
<th>Feet.</th>
</tr>
</thead>
<tbody>
<tr>
<td>Pennine Range, Cross Fell</td>
<td>2,892</td>
</tr>
<tr>
<td>Cumbrian group, Scaw Fell</td>
<td>3,208</td>
</tr>
<tr>
<td>Welsh Mountains, Snowdon</td>
<td>3,571</td>
</tr>
<tr>
<td>Devonian Range, Yes Tor</td>
<td>2,050</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Ireland</th>
<th>Feet.</th>
</tr>
</thead>
<tbody>
<tr>
<td>Mountains of Kerry, Carrantuohill</td>
<td>3,404</td>
</tr>
<tr>
<td>Connemara, Mwlrea</td>
<td>2,688</td>
</tr>
<tr>
<td>Mourne Mountains, Slieve Donard</td>
<td>2,788</td>
</tr>
<tr>
<td>Wicklow Hills, Lugnaquilla</td>
<td>3,039</td>
</tr>
</tbody>
</table>

37. The British System.—This system includes, as the term implies, the various ranges and groups of the British Islands, and has evidently a geological connection with the Scandinavian system, of which its component range may therefore be regarded as outlying members. Regarding the British System as a whole, we immediately perceive that its highest portions closely adjoin the western and northern coasts of both Great Britain and Ireland. It is also noticeable that the general trend or strike of the chief ranges is from south-west to north-east—a point of resemblance fully exemplified in both islands.

38. Commencing in the north of Great Britain, we find the irregularly-formed elevations of the wild and desolate Northern Highlands completely isolated by a deep and narrow valley—Glenmore—south of which extends the lofty and precipitous chain of the Grampians, the main range and outliers of which cover the country from the Mull of Cantire on the west, to Buchan Ness.

1 These fjords, or narrow salt-water estuaries, which admit the sea into the heart of the mountain-region, are a characteristic feature of Scandinavian geography. It is principally on their shores—sheltered in some degree from the fury of the storms which rage over the neighbouring ocean, or expend their strength upon the naked mountain-plain above—that the towns and villages of this singular country are built.
on the east. The eastern and central portions of the Grampians and outlying ranges are generally continuous and unbroken—the westerly division, from Ben Nevis to the Firth of Clyde, consists of isolated masses of considerable height. The main chain of the Grampians contain several peaks above 4,000 feet high, but the culminating point of the range, and also of the whole British system, is the isolated outlier of Ben Nevis, which rises abruptly from the eastern shores of Loch Eil to a height of only 150 feet below the limit of perpetual congelation. The broad plain of Strathmore intervenes between the Grampians and its southern outliers—the Ochil and Sidlaw Hills, and the Campsie Hills. The Southern Highlands of Scotland embrace the border range of the Cheviots, and its westerly continuation—the Lowther Hills—both of which are of very moderate elevation.

39. The high grounds of England are also naturally divisible into three main sections, forming a succession of elevated regions, stretching nearly from the borders of Scotland to Lands' End, and seldom far removed from the western coasts. The northern section includes the Pennine Range and Cumbrian group. The Pennine Range extends from the Cheviots to the banks of the Trent, and constitutes the most continuous elevated tract in England. This range is for the most part bleak and treeless, but the wild and romantic district of the Peak, in Derbyshire, is one of the most picturesque in Britain. The adjacent Cumbrian group is more rugged and elevated, and contains several beautiful lakes embosomed in long and narrow valleys. The mountains of Wales spread over the greater part of the principality, and confer upon it its distinctive mountainous character. "They consist neither of a single range nor a succession of mountain-chains. They form rather a high mountain region, in some places spreading into broad masses of table-land, intersected by deep valleys; and in others forming huge mountain-summits, which rise conspicuously above the surrounding ground." The culminating point of the system is Snowdon, which rises higher than any other mountain in England and Wales. In South Wales, the various hill-ranges culminate in the Brecon Beacon. South of the Bristol Channel a series of granite hill-ranges extends through Cornwall and Devon, forming the so-called Devonian System, which is much less elevated than the Cumbrian or the Pennine Systems, but still impart a varied and rugged character to the districts they traverse. Of the other hill-ranges of England, the principal are the Cotswold and Chiltern Hills, and the North and South Downs.

40. With the exception of the Silver Mine and Slieve Bloom Mountains, all the mountains of Ireland closely adjoin the coast, but nowhere do they form continuous chains like the Grampians in Scotland, or the Pennine Range in England. Of the various groups of elevations, the principal are the picturesque Wicklow Hills, the granitic Mourne Mountains, and the mountains—or rather plateau—of Antrim, in the east; the Sperrin Mountains, and Mountains of Donegal, in the north; the wild and rugged Mountains of Connemara, in the west; and the Mountains of Kerry, in the south-west. The latter consist of several parallel ranges, separated from each other by arms of the sea. Although the general direction of the Irish ranges is the same as that of the English and
Scotch mountains—that is, from south-west to north-east—they are much less elevated; the scenery, however, is in many parts extremely varied and beautiful, especially in Wicklow, Kerry, and Galway.

41. The Sarmatian System.—This system embraces the slightly elevated plateau which extends from the Baltic to the Uralian Mountains, and which is geographically important only as forming the great water-parting of Russia, separating the basins of the rivers flowing into the White Sea and the Baltic, from those flowing into the Black Sea and the Caspian. The mean elevation of the highest portion of the system—the Valdai Hills—does not exceed 1,000 feet.

| The Uralian System. |
|---------------------|------------------|
| **Feet.** | **Feet.** |
| Northern Ural, Toll Poss | 5,540 |
| Southern Ural, Iremel | 5,040 |
| Central Ural, Konjakovski | 5,397 |

42. The Uralian System.—This system includes the chain of the Ural Mountains, which is remarkable (1) as forming the natural boundary between Europe and Asia, and the water-parting between the basins of the Petchora and the Volga, and that of the Obi; and (2) as trending in an entirely different direction to the other great ranges of Europe—the general direction of which, as we have already observed, being from south-west to north-east, while the Ural range trends almost due north and south, on or near the 60th meridian.

This range is also remarkable for its great length and continuity,—extending in an almost unbroken line from the shores of the Sea of Kara to the banks of the Ural, near Orenburg, a distance of more than 1,200 miles, and being besides prolonged on the north, through the entire length of the Novaia Zemla group to Cape Nassau, and on the south of the Moughojar Hills into the Ust-Urt plateau, between the Sea of Aral and the Caspian. The main chain is flanked on either side by minor parallel ranges, which are less numerous, and not so close together in the north as they are in the south, where the entire width is upwards of 100 miles. The range is throughout of very moderate elevation—the average height being scarcely 2,000 feet, and few points rising above 5,000 feet. It is remarkably rich in minerals and metals, but it exhibits none of the precipitous peaks and gorges of the Alpine System. Indeed, it would seem “as if the upheaving force, whose general feebleness is manifested over the whole of this vast region, had overcome the superposed weight, but not to shatter rocks or throw up cones.”

43. The Mountain Systems of Asia.—We have already observed that the main portion of the great highland belt of the Old World is in Central Asia, where the stupendous ranges of the Himalaya,
Thian Shan, &c., radiating from the remarkable "boss" of the Pamir, enclose the loftiest and most extensive table-land in the world. But—unlike the Alps, the Uralian, Scandinavian, and Iberian Mountains, which form well-marked distinct systems—the great ranges of Asia, from the shores of the Ågean to the Strait of Behring, form a belt of high ground, the continuity of which is such that any subdivision into systems will necessarily be more or less arbitrary. Such subdivision being, however, necessary for convenience of description, we may divide the main-belt into three systems—the Western, embracing the ranges between the Ågean coast and the lower Indus—the Central, comprising the various ranges that buttress or traverse the great table-land of Central Asia—and the Eastern, including the whole of the ranges that lie on or near the eastern coast of the continent from Behring's Strait to Cape Romania, the terminal headland of the Malay Peninsula. Besides these, we have two isolated sub-systems, viz., those of Arabia and Peninsular India, which may, perhaps, be best described in connection with the western and central systems respectively.

### The Western System.

<table>
<thead>
<tr>
<th>Feet</th>
<th>Feet</th>
</tr>
</thead>
<tbody>
<tr>
<td>The Caucasus, Mt. Elburz ... 18,526</td>
<td>Lebanon, Mount Hermon .... 10,000</td>
</tr>
<tr>
<td>Armenian Mts., Mt. Ararat 17,260</td>
<td>Sinai Mountains,</td>
</tr>
<tr>
<td>Euxine Hills, Kheshish Dagh 6,332</td>
<td>Arabian Mountains, Akdar... 9,900</td>
</tr>
<tr>
<td>Taurus, Bulghar Dagh.......... 11,400</td>
<td>Zagros Mts., Kuh Dinar...... 18,000</td>
</tr>
<tr>
<td>Anti Taurus, Bingöl Dagh ... 11,550</td>
<td>Elburz Mts., Demavend ..... 20,086</td>
</tr>
</tbody>
</table>

44. The Western System.—This system embraces the various ranges of Asia Minor, Syria, Persia, Beluchistan, and Afghanistan, and is, perhaps, the most complex of the Asiatic systems.

The central point of this system is the snow-capped mass of Agri Dagh, or Mount Ararat, the culminating point of the Armenian highlands. Taking this magnificent cone (which, we may note, is equally distant from the Caspian, Black Sea, the Mediterranean, and Persian Gulf), as a centre, the actual and relative position of the several members of the system may be fairly traced—the Soghanly Mountains and Euxine hills, west; the Suram ridge, north, into the Caucasus; the Anti-Taurus, south-west, into the Taurus; the Zagros Mountains, south-east; and the Caspian Mountains, east. With the Taurus line of elevation are connected the Mountains of Syria, Palestine, and the Sinai peninsula, south-east of which lie the ranges and hills of Arabia. The Caspian range are connected by the so-called Paropamisan Mountains with the
Hindu Kush, and thus with the Central System: the Zagros Mountains curve along the shores of the Persian Gulf and Arabian Sea, towards the meridional ranges of the Hala and Suliman Mountains.

45. A transverse range, of no great elevation, dividing the head-waters of the Rion and Kur, unite the Armenian Mountains to the great chain of the Caucasus, which may be, and frequently is, regarded as a separate system. This remarkable range trends (E.S.E. to W.N.W.) from Baku, on the Caspian, to Anapa, on the Black Sea, and is bounded on the north by the Steppes, and on the south by the Black Sea and the deep valleys of the Rion and Kur. The western portion of the chain runs in an unbroken line for nearly 250 miles along the coast, its seaward slope being clothed with magnificent and almost impassable forests. The central portion of the range consists of several parallel ranges connected by broad plateaux, trenched here and there by narrow fissures. The main ridge is nowhere below 10,000 feet in height, consequently all the loftier peaks and ridges are covered with perpetual snow. But although the average height of the Caucasus exceeds that of the Alps, its glaciers are inferior both in number and extent. The main chain is composed nearly throughout of granitic rocks—the secondary ridges are of limestone formation, while the isolated peaks of Elburz, &c., are of volcanic origin. One noticeable feature in the Caucasus is the almost entire absence of passes—the only practicable passes being those of Dariel, on the eastern side of Mount Kasbeck, and that of Derbend, along the shore of the Caspian. The snow-line rises from 9,000 feet in the west, to 12,000 feet in the east. Of the rivers the chief are—the Terek and Kouban on the north and the Kur and Rion on the south. There are no lakes of any considerable size. The Caucasus resemble the Pyrenees in many respects. Like that chain it extends across a broad isthmus, is broken by few passes, and its culminating points are isolated cones detached from the main chain.

46. North-west of Mount Ararat, on the opposite side of the valley of the Aris, lie the Soghanly Mountains, extending west to the banks of the Joruk-su, near the mouth of which commences the long range of the Euxine Hills, rising steeply from the shores of the Black Sea, and trending irregularly along the coast, finally terminating in Cape Baba, the most westerly point of the Asiatic continent. This range forms the northern buttress of the interior plateau of Asia Minor, and decreases in height as it proceeds west. The Anti-Taurus range extends from the Armenian highlands, first west to the Euphrates, at Egin, and then south-west to the Gulek Boghaz Pass—the famous "Cilician Gates" of the ancients—which marks the western limit of the Taurus proper. The Taurus forms the southern border of the plateau towards the Mediter ranean, and is the best defined, though not the most lofty range in Asia Minor. The average height of the Taurus does not exceed 5,000 feet; one section of the Anti-Taurus—the Bingol Dagh—rises to 11,550 feet, and the Euxine Hills rise even in the west to upwards of 6,000 feet in Kheshish Dagh (the ancient

1 It should be noted, however, that Elburz and Kasbeck, the highest points in the Caucasus, are north of the main range; while the culminating points of the Pyrenees—Mont Perdu and Maladetta—are south of the principal chain.
Olympus). But the loftiest point of the peninsula is the isolated volcanic cone of Arjish Dagh, (the ancient Argeus), 13,000 feet, at the western extremity of the Anti-Taurus range.

47. An irregular and broken line of elevations also extends under various names from the head of the Gulf of Iskenderun to the southern point of the Sinai peninsula. In Syria, the most conspicuous section of these heights are the Mount Lebanon of the Bible, consisting of the twin chain of the Libanus and Anti-Libanus, between which is a narrow valley—the Cœle-Syria of classical geography. Although the higher summits of the Lebanon system do not exceed 9,000 or 10,000 feet in altitude, the culminating point—Jebel-esh-Sheikh, or Mount Hermon—is covered with snow during the greater part of the year. South of Mount Hermon the country consists of a high plateau, intersected by a deep ravine—the bed of the Jordan and the Dead Sea. Of the heights west of the Jordan valley, the more noticeable are Mount Carmel, 1,800 feet, rising from the southern shore of the Bay of Acre; Mount Tabor, 1,000 feet, in the interior; and Ebal and Gerizim, in Samaria. On the east, the mountains of Gilead and Seir continue the heights to the head of the Gulf of Akaba. South-west of the Dead Sea, a series of high and rocky plateaux extend to the mountains of Et-Tib, a transverse range marking the northern limit of the Sinai mountains, among which the granitic masses of Horeb and Sinai rise upwards of 9,000 feet above the sterile "wadies" and narrow plains of this inhospitable region.

48. The chain of Mount Seir, on the eastern side of the wady Arabah, is prolonged by a range of hills along the shores of the Gulf of Akaba, and thus unite the Syrian mountains with those of Arabia. With the exception of the narrow plain along the coast, and the northern desert sloping into the Euphrates valley, the whole of the Arabian peninsula forms a plateau—the seaward borders of which are marked by an irregular line of elevations skirting the coast at varying distances. Along the Red Sea coast, the outer border of the plateau is formed by a low range of hills, rising occasionally, however, to 6,000 feet. The southern coast is skirted by two parallel chains, or rather terraces, which merge in the mountains of Oman, the culminating point of which, Jebel Akhdar, attains an elevation of 9,900 feet, and is thus the loftiest summit in Arabia. The central plateau of Nejd culminates in the "twisted" chain of Jebel Toweyk. The northern secondary plateau of Shomer is crossed by two ranges—the Jebel Aja and Jebel Selma—the former of which is probably the loftiest of the interior ranges. None of these, however, exceed 6,000 feet in absolute height.

49. We have thus briefly noticed the western sections of the system. The eastern division consists of three well-defined sections, the Zagros Mountains—the Caspian, or Elburz range, and the Paropamisan Mountains—and the Hala and Suliman Mountains. These ranges enclose the Plateau of Iran, the Zagros Mountains forming its western and southern limit, the Caspian and Paropamisan Mountains its northern boundary, and the Suliman and Hala ranges its eastern edge, separating it from the plain of the Indus.

50. Under the general appellation of Zagros Mountains we may include the whole of those ranges which extend from the Armenian highlands to the Hala
Mountains. Thus viewed, the Zagros may be described as a series of parallel ranges, the outer range forming, first, the eastern boundary of the valley of the Tigris, and then abutting at varying distances on the narrow plain along the Persian Gulf and the coast of Beluchistan. Between this chain and the Kavir, or interior desert-plateau, are several other partially-explored ranges, portions of which appear to be covered with perpetual snow, and must therefore approximate, if not exceed, the Elburz in altitude. Of these chains, that known as the Kobraud Mountains rises in the north (Kuh Darbish), to 11,700 feet, and in the south (Kuh Hazal), to 14,450 feet. The continuations of the Zagros ranges in Beluchistan are much lower, and slope on the north into the stony valley of the Helmund, and curve on the east north with the outer chain of the Hala and Kurkleki ranges—which, with the loftier Suliman Mountains, form the eastern edge of the great Iranian Plateau, dividing it abruptly from the Indus valley. The term Caspian Mountains we apply to those ranges which radiate eastward from the common centre of the system in Armenia, along the southern bank of the Aras and the Caspian Sea, and with their offsets forming the northern boundary of the interior Plateau. The first section of these mountains traverses the rugged mountain-province of Azerbaijan, and rise in Savelan Dagh to a height of 14,000 feet. The main chain commences between the Savelan Dagh and the coast, and, under the name of Elburz Mountains, curves along the southern shores of the Caspian, at a distance of less than 50 miles, culminating in the volcanic cone of Demavend. A minor line of elevations, sometimes designated the Paropamisan Mountains, unites the Elburz range with the Hindu Kush, and thus with the great central system of Asiatic mountains. The mountains of northern Afghanistan, indeed, so merge in the central system, that north of the Kurum Pass there is no natural limit between the western and the central systems. South of the Kurum, however, the western system is definitely limited by the transverse ranges of the Suliman, Kurkleki, and Hala, the higher peaks of which rise from 5,000 to 10,000 feet above the great plain of the Indus.

<table>
<thead>
<tr>
<th>Central System.</th>
<th>Feet.</th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td>Himalaya, Mount Everest</td>
<td>.... 29,000</td>
<td>Feet.</td>
</tr>
<tr>
<td>Hindu Kush</td>
<td>.... 20,000</td>
<td>Thian Shan</td>
</tr>
<tr>
<td>Altai Mountains</td>
<td>.... 5,000-7,000</td>
<td></td>
</tr>
</tbody>
</table>

51. The Central System.—This system embraces those lofty ranges which, radiating from the central knot of the Pamir, enclose or traverse the vast table-land of Central Asia, and constitutes by far the loftiest, most extensive, and, physically, the most important mountain-system in the Old World. Its component members are fewer in number and better defined than those of the western system. Indeed, each of the three main ranges which spring eastward from the Pamir form distinct systems: the Himalaya, to the south-east— the Kuen Lun, east—and the Thian Shan, north-east. Of the ranges
which trend westwards from the common centre, the Hindu Kush only is worthy of special notice; being, indeed, the link between the western and the central systems of Asia. This magnificent range is second only to the Himalaya in elevation—many of its peaks rising upwards of 20,000 feet above the sea. It trends south-west for 400 miles to Bamian Pass, forming the water-parting between the Oxus and the Indus, and is prolonged westwards by Siah Koh and Safid Koh; the offsets of the latter of which ultimately join the Elburz range.

52. But the most conspicuous member of the system is the vast chain of the Himalaya, which surpasses all other known ranges in elevation, and which may be regarded as a type of mountain-formations on the grandest scale. The name of Himalaya—"dwelling of snow"—is given to the gigantic mountain-wall which forms, through an extent of 1,500 miles in the direction of east and west, the border of Northern India. The commencing portion of the mountain-region is throughout formed, along its southern base, by a chain of hills (known as the Siwalik Hills), which rise, in a well-defined line, above the plain, to an elevation varying from a few hundred to three or four thousand feet. Above the entire line of these hills there occurs a depression, beyond which—at a further distance of from five to ten miles—the great mountain region begins to rise, and stretches thence far to the northward, range above range. For a distance of sixty or seventy miles from the outer range, the mountains seldom exceed 10,000 feet in altitude. Thence they exhibit a more rapid ascent, and form at length that stupendous range of snowy peaks which surpass in elevation any other portions of the Earth's surface. The highest point of the Himalaya system is found in the eastern portion of the mountain-region, where Mount Everest (lat. 27° 59': long. 86° 58';) reaches 29,000 feet above the sea. This is the highest known elevation on the surface of the globe. Many of the adjacent mountain-masses are upwards of 20,000, and several exceed 24,000 feet in height. The line of the higher snow-covered peaks is here found generally at from eighty to ninety miles distance from the southern or outer edge of the chain. But the north-west-ly portion of the mountain-region, embracing the Mustakh and Karakoram ranges, appears to surpass any other in the general elevation of the entire mass. The highlands here spread out to a greater breadth than elsewhere, forming several distinct ranges, with long valleys (parallel to the general direction of the mountain-system) lying between. This portion of the mountain-system contains Dapsang, which reaches 28,278 feet, and Karakoram Peak, 28,265 feet.  

1 The meaning of the name, which is of Sanskrit origin.
2 Immediately below these hill-ranges, and stretching along their southern base, is a land of swampy country, about ten miles in breadth, covered with forest and jungle, and dreaded on account of its unhealthiness. This is known as the "Tarai," the abode of numberless wild animals, which find almost un molested refuge amongst its thickly-wooded and pestilentiai recesses. The narrow belt of the Tarai extends along the southern base of the sub-Himalaya region through its entire length, and is one of the most characteristic features in the geography of India.
3 Kinchin-jinga, within the eastern part of the mountain region, reaches 28,156 feet in height, and ranks fourth amongst the summits of the Himalaya chain: Dhaulagiri, which comes next in order of height, is 26,826 feet.
Within the central and eastern Himalaya, the greater peaks are not generally found on a continuous ridge, but grouped together in masses: these are separated one from the other by deep depressions, through which flow the streams that drain those parts of the contiguous plateau-region to the northward. The vast extent and stupendous elevation of the plateau—itself fifteen thousand feet above the sea-level—are, in truth, the most remarkable condition of the whole region. "After weeks," says Captain Strachey, "have been spent in traversing mountain after mountain, of the seeming interminable succession of which the eye begins to tire, while the incessant roar of the torrents that rush by begins to weary the ear, we are here suddenly arrested by seeing spread out before us a plain that, without sign of water, of vegetation, or of animal life, stretches away, as far as the eye can reach, in a north-westerly direction; behind which rise mountains that gradually fade away in the distance, with here and there only a peak lightly tipped with snow."

The snow-line on the Himalaya varies between 15,000 feet on the southern, and 18,000 feet on the northern side of the mountain-region. Glaciers abound in all those portions which rise above the snow-line, and some of them are of vast magnitude. Within the north-western portion of the mountain-region, the glaciers of the Mustakh range surpass in magnitude any others known—valleys of twenty, thirty, and even sixty miles in length being completely filled with continuous streams of ice. The lowest level to which they have been observed to descend is about 11,500 feet above the sea, and from that height to 12,000 feet is the ordinary elevation of their extremities. In those parts of the mountains which are to the northward of the great peaks, where the elevation of the snow-line is considerably increased, the lower extremities of the glaciers recede in a corresponding degree, the altitude at which they terminate being increased to about 16,000 feet.

53. It may be advisable to notice here the detached ranges and groups of Peninsular India, which are completely isolated from the great chain of the Himalaya by the plains of the Ganges and Indus. First we have the meridional chain of the Aravalli Hills, rising abruptly from the level expanse of the Thur to a mean height of about 3,000 feet, and sloping gradually on the east into the Plateau of Malwa, the southern edge of which is marked by the Vindhyâ Mountains. The Vindhyâ range extends from the head of the Gulf of Cambay towards the Ganges, and, like the Aravalli, presents an extremely steep counterslope towards the Narbudda valley, but slope gradually into the plateau behind. In fact, neither the Vindhyâ nor the Aravalli can properly be considered distinct ranges: their mean elevation does not much exceed that of the plateau on which they form the western and southern buttress. South of the Vindhyâ runs the parallel chain of the Satyura Mountains, rising step by step from the banks of the Narbudda, but descending steeply towards the Tapty. These mountains are prolonged eastwards to the banks of the Ganges as the Rajmahal Hills, forming what may be regarded as the northern boundary of the table-land of the Deccan. It is only on the west that the edge of this table-land is boldly marked. Here the precipitous escarpments of the Western Ghaouts rise abruptly from the narrow coast-plain at a distance of about 30 miles from the sea. The eastern edge of the plateau is not so well defined; the so-called
chain of the *Eastern Ghauts* consist of a succession of detached hills of no great height, at a considerable distance from the sea. South of Mysore the lofty group of the *Nilgherries*, rising abruptly from the remarkable valley or "gap" of Coimbatore, forms the connecting link between the Eastern and the Western Ghauts, and marks the southern edge of the Deccan. South of the gap are the *Aligherries* or Cardamum Mountains, which are remarkable as containing the highest mountain in India south of the Himalaya, viz.—Anamalli, 3,837 feet.

54. Vast and lofty though the Himalayan mountains be, they must, strictly speaking, be regarded not as a distinct chain, but rather as forming the outer, and therefore the most conspicuous portion of the vastly greater area of elevation beyond them. The same may be also said of the so-called range of the *Kuen-Lun*, which is generally marked as a continuous chain, extending from the Pamir eastwards (on or near the parallel of 35° N. lat.), to the Koko-nor Plateau. But the Kuen-Lun has no claim whatever to be regarded as a distinct chain, it being for the most part merely the northern flank of the Tibetan Plateau. This being so, the supposed connection traced by some geographers between the Elburz, the Kuen-Lun, and the Pe-ling, the "whole forming one great range," cannot be maintained, for the mere edge of a table-land cannot be regarded as a continuation of definite lines of elevations, such as the Elburz, &c.

55. The next member of the central system is the range of the Thian Shan, or Celestial Mountains, extending from the northern end of the Pamir, between Zoungaria and Eastern Turkestan, and with the Kuen Lun enclosing the bay-like basin of the Tarim river. In the west, the Thian Shan splits into several branches, two of which—the Ala Tau, and the Kara Tau—enclose the upper valley of the Jaxartes. Eastwards the main range rises considerably above the snow-line, but its glaciers are neither numerous nor extensive. Formerly the Thian Shan was supposed to be highly volcanic, and the lofty peaks of Pe-shan, Hochow, and Turian, were said to be the only active volcanoes at so great a distance (1,500 miles) from the sea. It is now, however, known that "of active volcanic phenomena, nothing is seen in Central Asia at the present day." Directly north of the Thian Shan, and connected with it by the minor hills and ranges of Soungaria, are the *Altai Mountains*, a term which is sometimes applied to the whole of the north-eastern chain, but which is here restricted to those ranges extending between the Upper Irtish and the Selenga. Thus defined, the Altai consists of three main chains—the Great Altai and the Russian Altai, between the Upper Irtish and the Obi, and the Sayan Mountains, the most northern chain between the Yenesei and the Selenga. The scenery is generally grand—precipitous peaks and gorges, lofty massive chains, and densely-wooded valleys, extensive glaciers and numerous rivers, combining to render the Altai the "Alps of Asia." The Altai are also extremely rich in minerals—the mines of gold, silver, copper, and iron, in the Russian Altai, rivaling those of the Ural Mountains in richness. The main ridges are chiefly of granitic and the newer
igneous formations, but there are no active volcanoes. Geologically, the Altai may be considered as "a vast promontory, connected on the south with the mainland of primitive rocks, and surrounded on the other three sides by an ocean of diluvial deposits." The Altai are united with the Ural Mountains by a series of low ranges, between the Steppe of Ishim and the great Kirghiz Steppe.

56. The Eastern System.—This system, which embraces the whole of the ranges of Eastern Asia from East Cape to Cape Romania, is virtually a continuation of the Central System: the Yablonoi and Stanovoi Mountains springing from the eastern end of the Altai—the Peling, and other Chinese ranges, trending east from the Kuen-Lun—and the various ranges of the Indo-Chinese Peninsula radiating from the Himalayan chain.

57. The Stanovoi Mountains extend in an unbroken line from East Cape to the source of the Aldan, near which it unites with the so-called Yablonoi Mountains. Of the numerous spurs of the Stanovoi, the chief are the Verhoianskoi Mountains, trending north, between the basins of the Aldan and the Indigirka; and the remarkable volcanic range which branches off from the main chain near the 65° N. lat., traverses the peninsula of Kamchatka from north to south, and terminates in Cape Lopatka. The general elevation of the main range is probably not more than 3,500 feet, but several of the volcanic peaks of Kamchatka are upwards of 10,000 feet in height, the culminating cone, Klinchevsk, indeed, rising several hundred feet higher than Mont Blanc, the highest summit in Europe. The Yablonoi Mountains are not mountains in the strict sense of the term; they appear rather to be a series of low and densely-wooded plateaux, stretching from the right bank of Selenga to the shores of the Sea of Okhotsk, near the mouth of the Amur, thus forming the water-parting between the basins of the Lena and the Amur. South of the Amur the system resolves itself into two chains—one in close proximity to the coast, the other far inland—forming, in fact, the eastern buttress of the Plateau of Mongolia. The former consists of the Sikkota Alin, which runs along the coast from the mouth of the Amur to Victoria Bay, where it joins the snow-clad Shan Alin range—south of which the lofty mountains of Corea trend south, rising steeply from the eastern coast to a height of from 5,000 to 8,000 feet. This chain is completely isolated by the Amur and its tributary the Sungari, and the Leao-ho, from the inner range—the Khin-ghan, which forms the eastern buttress of the Mongolian Plateau. Further south the edge of the great central table-land is marked by the In-shan, Nan-shan, Bhai-kauro-ula, and Yang-ling. The third of these ranges is prolonged eastwards between the Hoang-ho and the Yang-tsze-kiang, under the name of Peling, or Northern Mountains—the fourth reappears on the right bank of the Yang-tsze-kiang as the Nan-ling, or Southern Mountains. The Pe-ling range dips south-east in 113° W. long., and terminates in low hills about two degrees further east. The Nan-ling, on the contrary, after an almost direct course for 1,000 miles, curves abruptly north-east, at a point about 150 miles west of Amoy; and, under the name of Ta-ju-ling, or Bohea Mountains, trends in that direction parallel to the coast for 400 miles, finally terminating in the hilly region west of Hang-chow. Both the Nan-ling
and the Yung-ling rise in some places far above the snow-line. Of the minor ranges of China proper the principal are the Ta-pa-ling, a southerly spur of the Pe-ling range, and the Yu-ling, a moderately-elevated ridge, between the basins of the Canton river and the Song-ka. From the lofty mountain-mass in the south-east of Tibet, between the Brahmaputra and the Yang-tsze-kiang, a series of more or less defined ranges radiate south and south-east between the various rivers of Further India. These ranges are as yet scarcely known, especially in the interior of Siam, Burma, and Anam. The mountains of Siam appear to be continued south through the Malayan peninsula, to Cape Romania.

<table>
<thead>
<tr>
<th>Mountain-Systems of Africa.</th>
<th>Feet</th>
</tr>
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<tbody>
<tr>
<td><strong>Northern System</strong></td>
<td></td>
</tr>
<tr>
<td>Mount Atlas, Miltsin</td>
<td>11,400</td>
</tr>
<tr>
<td><strong>Western System</strong></td>
<td></td>
</tr>
<tr>
<td>Kong Mountains</td>
<td>3,000</td>
</tr>
<tr>
<td>Cameroon Mountains, Mount Albert</td>
<td>13,760</td>
</tr>
<tr>
<td><strong>Southern System</strong></td>
<td></td>
</tr>
<tr>
<td>Sneeuwberg, Compassberg</td>
<td>8,000</td>
</tr>
<tr>
<td>Nieuweld</td>
<td>7,000</td>
</tr>
<tr>
<td>Drakenberg, Catkin Peak</td>
<td>10,370</td>
</tr>
<tr>
<td>Lupata Mountains</td>
<td></td>
</tr>
<tr>
<td>Livingstone Mountains</td>
<td>11,000</td>
</tr>
<tr>
<td>Kenya and Kilimanjaro</td>
<td><em>each over 18,000</em></td>
</tr>
</tbody>
</table>

58. The Mountain-Systems of Africa.—One of the most striking features in the relief of the African continent is the general parallelism and proximity of all the principal mountain-ranges to the sea-board. Indeed, the whole of the African coast—with the exception of about 1,500 miles between Cape Nun and Cape Verde, and at the mouths of the Nile—is almost invariably bordered by more or less lofty ranges, sloping in some places immediately from the sea, but lying generally at a distance of from 50 to 200 miles inland. With the exception of a few ranges discovered within recent years in the interior, we may group the African ranges in four systems, according to their position; viz.—the Northern System, embracing the Atlas ranges, and the hills of Tripoli and Barca; the Western System, comprising the Kong Mountains, and the various ranges which trend along the coast from the Niger to the Orange river; the Southern System, including the parallel chains of the Cape Colony; and the Eastern System, embracing the Drakenberg, Lupata, and other ranges skirting the east coast, together with the lofty group of Abyssinia, and the wall-like heights that line the western shore of the Red Sea. To these we may add the Central System, a general term, embracing the interior ranges at present
known, of which we know too little to enable us to trace them definitely, and arrange them accordingly. We may, however, broadly distinguish two sections, corresponding to the two great physical divisions of the continent; viz.—the North-Central, embracing the highlands of the Sahara; and the South-Central, comprising the as yet imperfectly-known ranges that traverse the great South African Plateau: the western and eastern edge of which are marked by the ridges included in the western and eastern systems.

59. The Northern System.—The most prominent member of this system is the great chain of Mount Atlas, stretching parallel to the coast from Morocco to Tunis. The Atlas consists of a series of ranges, generally parallel to each other, and connected by high plateaux, but frequently isolated by deep valleys and gorges. The main chain extends from Cape Nun on the Atlantic to Cape Bon on the Mediterranean, a distance of about 1,500 miles. Between Cape Bon and the opposite Sicilian coast is a remarkable sub-marine ridge, which evidently points to a former connection between the Atlas and the Sicilian Mountains. The western portion of the Atlas is the loftiest; here Mount Miltzin, near the city of Morocco, rises to a height of 11,400 feet; and other peaks are supposed to attain a much greater elevation. In Algeria and Tunis the average height of the chain varies between 3,000 and 4,000 feet. The snow-line lies at a height of about 10,000 feet, so that only the higher peaks are covered with perpetual snow. In appearance the Atlas Mountains resemble the Urals rather than the Alps—broad ridges and rounded summits being the general form. The Atlas proper do not extend beyond the Tunisian coast, but the low sandy hills which flank it on the south are continued along the coast of Tripoli to the plateau of Barca, beyond which the hills gradually sink to the dead level of the Nilotic Delta.

60. The Western System.—From Cape Nun to Cape Verde, a distance of more than 1,500 miles, the shifting sandhills of the Sahara extend to the coast, unchecked by any elevation. South of Cape Verde the mountains of Senegambia and Guinea exhibit a line of heights, running along the coast at a maximum distance of about 200 miles. The former are lofty, and contain the sources of the three great rivers of this region; the Senegal, Gambia, and Niger—the latter, known as the Mountains of Kong, nowhere exceed 3,000 feet in height. East of the Niger several ranges appear to trend eastwards into the interior; the seaward range curves south, approaching, at the head of the Bight of Biafra, the isolated volcanic group of the Cameroon Mountains, rising in Mount Albert to a height of 13,760 feet. This group evidently belongs to the remarkable line of volcanic heights extending from Mount Mendif in the interior, south of Lake Chad, to the Island of Annabon, in the Atlantic.¹ South of the Cameroons the western edge of the interior plateau is more or less distinctly

¹ This line of volcanic heights consists of Mount Mendif, 6,000 feet; Atlantika, 8,235 feet; Cameroons, 13,760 feet; Fernando Po (Clarence Peak, 10,190 feet); Princes Island, St. Thomas, and Annabon, and probably the far distant island of St. Helena.
traced in (1) the Sierra do Crystal, between the Cameroons river and the Ogowai; (2) the Sierra Complida, between the Ogowai and the Congo; (3) the broken chains of Benguela and Angola; and (4) the barren ranges of Damara-land, and Namaqualand. The average elevation of these ranges is probably not much above 4,000 or 5,000 feet, but Mount Omatoko, in Damara-land, attains an elevation of 8,800 feet, while the Sierra Complida is supposed to rise in some places to at least 12,000 feet.

61. The Southern System.—This system belongs to the extreme south of Africa, and consists of a series of parallel ranges, rising along the edges of the characteristic terrace-plateaux of this region. First we have a long range extending along the south coast, at a distance of from 10 to 50 miles, known in the east as the Outeniqua Range, and further west as the Swellendam Mountains, curving north parallel to the coast as the Drakenstein and Oliphantberg. The first terrace-plateau (the Kannaland Karroo and Long Kloof) intervenes between this range and the loftier and more marked Zwarteberg or Black Mountains, beyond which the broad upland of the Great Karroo extends to the base of the main range of the system. This chain extends, under various names, from the Drakenberg Mountains on the east, to the 20th meridian, and is continued by the broken hills and groups of Namaqualand to the banks of the Orange. It marks the southern border of the great South African Plateau, and its central portion, the Sneeuberg, rises in Compassberg, the culminating point of the system, to an elevation of 8,500 feet above the sea. Both the Zwarteberg and the Nieuweld, as the western portion of the main range is called, curve north with the coast; the former as the Bokkeveld, and the latter as the Roggeveld. Like many other ranges (e.g. the Western Ghauts) which mark the outer edges of upland plains or table-lands, the sea-ward faces of the Cape Mountains are steep, while on the other side the slope is comparatively gradual. The main ranges are frequently broken by narrow defiles, by which alone access from one terrace to another is possible. The higher ridges and summits are nearly everywhere flat-topped; the most remarkable instance of this formation being Table-Mountain, the culminating point of an isolated group of heights near the Cape of Good Hope.

62. The Eastern System.—This system comprises the whole of the coast ranges of Eastern Africa, from the borders of Cape Colony to Abyssinia. Like those of the western system, these ranges for the most part buttress the great Central Plateau, but they are generally loftier, and descend much more abruptly to the coast plains. Our knowledge of this system is at present imperfect; between the Limpopo and southern Abyssinia the chain has been crossed at many points, but the connection between the several sections is not as yet fully determined. The extreme southern portion of the system, from the Stormberg to the banks of the Limpopo, consists of the great range of the Drakenberg, or Quathlamba, which extends almost parallel with the coast for several hundred miles, and rises in Catkin Peak, on the western border of Natal, to a height of 10,370 feet. From the adjoining peak of Mont Aux Sources, a spur known as the Maluti Mountains traverses Basutoland, while another branch, the White Mountains, curves into the Orange Free State. The colony of Natal, between the main
chain and the sea, presents the same peculiar terraciform aspect as in the
Cape Colony, but the various terraces are not so well marked. Within the
Transvaal the Drakenberg gradually decrease in height as they approach the
Limpopo, but Mauch Peak, near Leydenburg, attains the comparatively high
elevation of 7,180 feet. Between this portion of the range and the sea, the
descent is marked by the minor ranges of the Makonjwa Mountains, and the
Lebombo Range; the latter of which rises from the low coast plain of Delagoa-
Bay to a height of 2,000 feet. North of the Limpopo the edge of the plateau
is still definitely marked by the Fura and Lupata Mountains, through which
the Zambezi breaks at the gorge below Tete. Then follows the region of the
great lakes. Between the Livingstone Mountains, which wall in Lake Nyassa on
the east, and the sea, are several minor ranges, trending north parallel to the coast.
About 300 miles west of Zanzibar are the Rubeho Mountains, north of which,
between the Victoria Nyanza and the sea, the margin of the plateau is marked
by a lofty range, rising in Kenia and Kilimanjaro far above the limit of per-
petual snow. Thence the line of elevation is most probably continued without
interruption to the great plateau of Abyssinia, the eastern edge of which rises
steeply from the low plain of the Danakil to a height of 7,000 or 8,000 feet.
The more marked natural features of this remarkable region have been
graphically described by a recent writer, as consisting of a "vast series of table-
lands, of various and often of great elevations, and of numerous high and
rugged mountains, some of them of very singular forms, dispersed over the
surface in apparently the wildest confusion, and everywhere intersected by
tremendous ravines, which are often of appalling depth, and are rendered more
hideous by their impenetrable gloom, their summits frequently not being more
than 200 or 300 yards asunder." The Alps of Semen, which contain the sources
of the Tacasse, are most probably the loftiest portion of the Abyssinian system;
their culminating point, the snow-capped peak of Ras Dashan, attains an
elevation of 15,160 feet, or more than 2,000 feet above the snow-line. From
Mount Taranta, on the north-eastern edge of the plateau, a chain of minor
elevations runs along the western shores of the Red Sea, rising in the Emerald
Mountains to a height of 9,600 feet, and finally terminating in Jebel Attaka,
(2,600 feet), near the head of the Gulf of Suez.

63. Central System.—We have already remarked that our knowledge of the
interior ranges is as yet too scant and imperfect to enable us to arrange them
into definite systems. This division is, therefore, purely arbitrary, as also is its
sub-division into north-central and south-central sections. In the former section
we may include the various hills and ranges of the Sahara; the highest of which,
the Tarco Mountains, and the Mountains of Ahir, or Asben, do not exceed
2,000 feet in height. The south-central section comprises the various ranges
which traverse the great Southern Plateau. West of the Albert Nyanza the
Blue Mountains rise to a height of at least 10,000 feet; further south the ridge
attains an equal elevation in Mount M'fumbiro, whence a range curves east, be-
tween the Victoria Nyanza and Lake Tanganyika, to the snow-capped Mount
Kilimanjaro. It is probable that a line of elevations connects the Blue
Mountains with the Cameroon range on the west coast, thus completing the
water-parting between the basins of the Nile and the Congo. Further south we
have the Urungu Mountains, between Lakes Tanganyika and Bangweolo, containing the intimate sources of the Congo; Kirk Mountains, west of Lake Nyanza, from which the Lokenda and Impume Mountains extend west to the Moxambó Ridge, an elevated chain in the interior of Angola. These ranges form the water-parting between the Congo and the Zambesi. South of the latter river the Lupata chain sends off a minor branch south-west—the Mashona and Matabo Mountains—a granitic range, with an average height of 4,000 feet, dividing the basin of the Limpopo from the inland drainage area of Lake Ngami.

64. The Mountain-Systems of Australia.—The characteristic feature in the relief of Australia, as in Africa, is the general parallelism and proximity of the higher grounds to the coasts. These are most connected and of greater altitude on the eastern side of the continent, where they form a continuous cordillera or chain of heights, extending along the coast from Cape Howe to Cape York.

65. The south-eastern portion of this long chain, known as the Australian Alps, is by far the loftiest; its culminating point, Kosciusko, attaining an elevation of 7,308 feet, about 700 feet below the limit of perpetual snow. Further north the various ranges bear the general names of Blue Mountains, Liverpool Range, and New England Range, none of which exceed 5,000 feet in absolute height. The high grounds are continued along the coast, and finally terminate in Cape York, the northernmost extremity of the continent. "In general, the Australian cordillera is composed of crystalline rocks, exhibiting a basis of granite, pierced through by porphyry, greenstone, and other trap-formation, or, in many other localities, by mica slate and other metamorphic rocks. The Blue Mountains, however, which are singularly rugged in aspect, consist principally of sandstone, and are scored with deep ravines, the sides of which are in many places inaccessible."[1]

66 In Victoria, besides the great dividing range, there are other ranges, of which the chief are the Grampians and the Pyrenees. In South Australia the principal range runs from Cape Jervis along the eastern coast of the St. Vincent and Spencer Gulfs. It is known in the north as the Flinders Range, and is composed for the most part of the older or Silurian rocks. In Eyria Peninsula, on the western side of Spencer Gulf, is a rugged chain of hills called the Gawler Range. North-west of Lake Torrens is Stuart Range, and further north, in the interior, are other ranges of much less elevation than the coast ranges. The western coasts are also backed by high grounds of moderate elevation, the principal section of which, bearing the name of Darling Range, lies parallel to the western coast, at a distance of from 10 to 25 miles. North of the Darling Range, the Herschel and Victoria Ranges continue the coast elevations to Shark Bay. Many similar tracts of high ground adjoin the north-western and northern coasts; but, as far as known, they nowhere exhibit the character of mountain-chains.

67. The mountains of Tasmania are naturally divided into two sections—
eastern and western—by the valleys of the Tamar and Derwent. The eastern
section may be considered as an outlying member of the great Australian cordil-
ters. It winds along the coast at an average distance of about 40 miles, rising on
an average upwards of 3,500 feet. The western section consists of an elevated
plateau, from which numerous ranges radiate north, west, and south. Several
peaks attain an elevation of 4,000 feet. Cradle Mountain, the culminating
point of the colony, rises to 5,069 feet.

68. New Zealand is crossed by an extensive and lofty chain of mountains,
known as the Southern Alps, in South Island; and the Ruahine Range, &c., in
North Island. The former stretch along the western coast for nearly 200 miles,
and rise in the snow-capped peak of Mount Cook to the great height of 13,200
feet. In North Island the chain consists of several parallel ranges, the highest
summits of which are, however, inferior in height to the detached volcanic cones
of Ruapehui, 9,195 feet, and Mount Egmont, 8,270 feet. North of the former
is the active volcano of Tongariro. "The formation of the northern portion of
New Zealand is principally volcanic, with some few primary rocks; of the South
Island it is essentially sedimentary. The North Island abounds with volcanic
cones, geysers, lava fields, and lakes, caused by subsidence, volcanic action in
all quarters being apparent. In the South Island are ranges of slate and granite,
topped by snow, wide glacial deposits, and alpine lakes."

EXAMINATION QUESTIONS.

1. In what direction do the greater number of the peninsulas point?
2. What mountain-chains in Europe lie in the direction of east and west? In
   Asia? In Africa?
3. Enumerate some of the principal plateaux in Asia, Europe, and Africa re-
   spectively.
4. Within what part of the Old World do we find an extensive belt of desert?
5. What is an oasis? Give some account of its features.
6. What kinds of variety do mountains exhibit in their external shape and aspect?
7. What kind of connection is to be observed between the external aspect of various
   regions, and their geological structure?
8. Name the principal mountain-systems of Europe, Asia, and Africa.
9. What are the characteristic features of the Iberian System?
10. Give a brief description of the Alpine System.
11. In what respects do the Scandinavian Mountains differ from the other ranges of
    Europe?
12. Give some account of the general features of the British, Sarmatian, and Uralian
    Systems.
13. Describe briefly the Western System of Asia.
14. What ranges are included in the Central System of Asia? Give some particulars
    of each.
15. State what you know of the Eastern System.
16. Describe briefly the four chief mountain-systems of Africa, adding a few particu-
    lars relative to the interior ranges.
17. Give some account of the mountains of Australia and New Zealand.
V.

THE HIGHLANDS OF THE NEW WORLD.

1. General Direction.—It has been already stated that the highlands of the New World follow a general direction of north and south. They are of inferior height to those of the Asiatic continent, but are distinguished by their vast prolongation; stretching in unbroken continuity through the entire length of America, from the shore of the Arctic Ocean to Cape Horn. Here, as in the Old World, the plateau-lands and mountain-chains are inseparable features—different portions, merely, of the same elevated regions.

2. Plateaux.—The principal table-lands of the New World, proceeding from north to south, are—

<table>
<thead>
<tr>
<th>North America</th>
<th>Mean Elevation</th>
</tr>
</thead>
<tbody>
<tr>
<td>Utah</td>
<td>5,000 feet</td>
</tr>
<tr>
<td>Mexico</td>
<td>7,000 &quot;</td>
</tr>
<tr>
<td>Central America</td>
<td></td>
</tr>
<tr>
<td>Guatemala, &amp;c.</td>
<td>3,500 &quot;</td>
</tr>
<tr>
<td>Quito (Ecuador)</td>
<td>9,000 &quot;</td>
</tr>
<tr>
<td>Pasco</td>
<td>11,000 &quot;</td>
</tr>
<tr>
<td>South America</td>
<td></td>
</tr>
<tr>
<td>Titicaca</td>
<td>13,000 &quot;</td>
</tr>
<tr>
<td>El-Despoblado</td>
<td>13,000 &quot;</td>
</tr>
<tr>
<td>Brazil, interior of...</td>
<td>1,500 &quot;</td>
</tr>
</tbody>
</table>

3. These, however, occupy a much less extensive portion of the New World than the regions of corresponding formation do of the eastern half of the globe. It is in the Asiatic continent that the plateau-formation is seen in its fullest proportions. The highlands of Asia spread from the neighbourhood of the Indian Ocean over vast regions of the interior. Those of the New World are limited, for the most part, to the neighbourhood of the western coasts, and are compressed between the Cordilleras of the mountain-region which borders the Pacific upon the side of America.
[The influence which these elevated land masses exert upon climate is surpassingly great. The interior plains of Mexico, which are traversed by the line of the northern tropic, enjoy a moderate (and even cool) temperature, while the low tract of country at their base, lying along the waters of the Mexican Gulf, suffers from the moist heats and pestilential vapours of the torrid zone. Even under the line of the equator, the inhabitants of the elevated valley of Quito luxuriate in a cool and equable atmosphere—a perpetual spring, the serenity of which is seldom interrupted, though storms expend their wildest rage within the regions below. In southern Asia, the elevated plateaux which belong to the mountain-region serve as sanitariums, wherein the exhausted dweller in the hot plains may recruit his strength by inhaling a purer air, and enjoying the advantages of an invigorating breeze unknown in such latitudes at lower heights.]

4. Mountain-Systems.—The mountain-systems of the New World are much less complicated than those of the Old World. There is, indeed, but one system of any great magnitude; consisting of a vast chain extending along the western side of the continent for upwards of three thousand miles. There are also three other mountain-systems on the eastern side of the continent, vastly inferior both in extent and in altitude to the western system. The latter consists of two main sections; the Andes, in South America, connected by the central American and Mexican highlands with the Rocky Mountains in North America. The minor systems are—the Alleghany system, in North America; the Parime; and the Brazilian system, in South America.

5. The Western System.—This system consists of the Andes and the Rocky Mountains, extending in an almost unbroken line from Cape Froward to Cape Barrow, and surpasses even the great Himalayan system in point of continuity. In point of altitude, the Andean section of the system makes nearer approach to the Himalaya than any other mountain-chain on the earth's surface.

6. The Andes exhibit three (or, towards their northernmost extremity, four) nearly parallel chains, or cordilleras. These become reduced, in the passage of the mountain-system through Peru and Bolivia, to two enclosing chains, between which are the loftiest table-lands of the New World. In Chili the mountain-system is narrowed to a single chain, which finally terminates in the barren island-region of Tierra del Fuego, and the adjacent rocks of Cape Horn, where it sinks beneath the waters of the Southern Ocean.
7. The equatorial Andes include Chimborazo, 21,415 feet, at one time regarded as the highest elevation on the surface of the globe, besides many other lofty summits—several of them volcanoes—which border upon either side the high table-land of Quito. But the mountains that enclose the Peruvian and Bolivian plateaux attain a superior altitude, and contain a greater number of snow-covered summits than any other portion of the Andean system. The average elevation of the ranges is here from 12,000 to 14,000 feet, and the highest summits reach an additional altitude of eight or nine thousand feet. Among the stupendous masses which lie grouped around the table-land of Titicaca, between the 14th and 19th parallels, several exceed 20,000 feet: Sahama, the highest measured among them, is 22,350 feet, and the summit of Lirima, further to the southward, has been conjectured to reach 24,000 feet above the sea. The culminating summit of the New World, however, lies on the eastern side of Lake Titicaca, where Sorata attains an elevation of 24,812 feet. To the southward, the highest among the measured summits of the Andes is the mountain called Aconcagua, one of the many volcanic cones found within that portion of the mountain-system which forms the eastern border of Chili. The entire range of the Chilian Andes exhibits a succession of lofty peaks, the average height of the mountain-crest being there at least twelve thousand feet. Several of the passes over this part of the chain are upwards of 12,000 feet above the sea.

8. In Patagonia, the mountain-system diminishes in altitude, its higher summits, however, still reaching between seven and eight thousand feet, until the chain declines, ere reaching Cape Horn, to less than half that altitude. The Patagonian Andes—unlike other parts of the chain—rise abruptly out of the waters of the ocean, which they immediately adjoin. Along the whole extent of western Patagonia, the coast is indented by deep and narrow inlets, which penetrate within the mountain mass in a similar manner to the fiords of the Norwegian sea-board. The islands which line this part of the coast—sometimes embraced under the name of the Patagonian archipelago—are portions of the mountain region severed from the mainland by deep channels, upon either side of which there rise walls of nearly perpendicular rock. Similar deep channels divide the numerous islands which are comprehended under the appellation of Tierra del Fuego, that is, "Land of Fire"—a name inappropriately bestowed upon so cold and desolate a region.

[The passes over the Andes rival those of the Himalaya in height—some of them attaining an altitude of 15,000 feet. Terribly hazardous, in some cases, is the passage through the wild and deep glens which they traverse, where the road consists only of a narrow mule-track along the steep face of a precipitous cliff, and a single false step would precipitate the traveller into the abyss which yawns beneath. Nor is the road, in the greater number of cases, practicable even for mules, or anything more than a mere footpath. So great, indeed, are the impediments which the mountain-chain interposes to commercial intercourse, that the productions belonging to the eastern slope of the cordillera may be conveyed thence to the shores of the Atlantic, a distance of 3,000 miles, with infinitely greater facility, and economy both of time and money, than to the
coasts of the Pacific Ocean, though the latter are less than a hundred miles distant. The city of Quito is, for all purposes of commerce, actually nearer to the Atlantic Ocean than to the Pacific, for the river Pastaza, a tributary of the Amazon, is navigable for steamers of three hundred tons burden to within 150 miles of Quito, and the eastern slope of the cordillera is comparatively easy of ascent; whereas the western descent of the mountains lies through a variety of lower ridges, so difficult of passage that goods are sometimes delayed a twelve-month on the transit between Guayaquil, the chief port of the state of Ecuador, and Quito, its capital. So great are the influences which result from the facilities for intercommunication afforded by rivers, and the difficulties interposed by mountain-chains!

Farther to the south, however, the passes which traverse the mountain-system are more practicable of transit, and offer greater facilities for commerce. The San Francisco Pass, which traverses the Chilian Andes, in lat. 27° S., at an altitude of 15,000 feet, is never wholly blocked up by snow, and it has even been proposed to carry a line of railway over its summit. Most of the passes in that portion of the mountain-chain are blocked up by snow during three or four months of each year.]

9. One important feature of the Andes—regarding the system as a whole—is their coincidence with a vast line of subterranean heat. In no other part of the world are there so many active volcanoes, and nowhere else is the destructive force of the earthquake experienced with so much frequency, or with such tremendous power. The country along the western foot of the Chilian and Peruvian Andes has, within comparatively recent periods, been repeatedly convulsed by violent earthquakes, resulting in the complete destruction of towns and other works of man; and on some occasions whole tracts of country, embracing many thousands of square miles, have had their levels permanently altered by these frightful shocks. It is in the Andes of Chili, and again in the immediate neighbourhood of the equator, that the number of active cones of eruption is greatest.

10. In this vast mountain-system—prolonged through more than sixty degrees of latitude—the conditions of climate are of course infinitely varied. These differences correspond not merely to successive heights above the sea, but also to distance from the equator. The general direction of the mountain-chains of the New World is attended in this regard by results different from those that ensue in the case of ranges which, like those of the Asiatic continent, have a direction coincident with that of parallels of latitude, and hence experience at corresponding heights, similar (or nearly similar) conditions of climate throughout their extent. In the Andes of Quito, under the equator, the line of perpetual snow is reached at 15,800 feet above the sea. In the Bolivian Andes, it recedes to a greater altitude, owing probably to the increased proportions of the mountain-region, and the greater breadth of the plateaux which it there embraces. The snow-line ranges, in that portion of the system, from 15,900 to upwards of 18,000 feet. In the Andes of Chili, it gradually declines from 14,000 to 6,000 feet, with the successive advance into a more southern latitude, and on the shore of the Strait of Magellan descends as low as 3,390.
11. The Andes form a portion only of the masses of highland which border the Pacific coasts of the New World. In the narrow region of the Mexican isthmus—including under that name the entire tract which extends from the Gulf of Darien to the parallel of 26° N. latitude—the high grounds fill up nearly the whole space between the Pacific and Atlantic oceans. The cordilleras which traverse the isthmus of Panama form an unbroken range, varying from 900 to 1,600 feet in height, from which branch off a number of subsidiary ranges; the whole tract of country, to the top of the highest summits, being covered by a dense forest, with a growth of underwood so thick as to make it difficult to cut a way through. In Guatemala and the other states of Central America, the line of the highest peaks borders closely on the Pacific, while the plateau-region spreads over the larger portion of the interior. Many of the peaks are active volcanoes. The Mexican table-land—further to the north—exhibits numerous insulated volcanic cones, amongst which the mountain known as Popocatepetl reaches 17,773 feet, and the peak of Orizaba (or Citlaltepetl) 17,373 feet above the sea. But as these mountains rise from a base which is elevated hardly less than nine thousand feet, their actual height, relatively to locality, is much less considerable. The chain of the Sierra Madre, which stretches through great part of Mexico in the direction of south-east and north-west, coincides with the general line of watershed between the two oceans; but it is only towards the upper portion of the valley of the Rio Grande del Norte, and to the northward of the 32nd parallel, that the dividing mountains assume the true character of a lofty and well-defined system, and it is there that the Rocky Mountains commence.

12. The Rocky Mountains form the great dividing chain or axis of the North American continent, and are prolonged in a northwardly direction as far as the shores of the Polar Ocean. Their highest points are found between the parallels of 50° and 55°, where several of the summits reach elevations little (if it all) short of 16,000 feet. The more southwardly division of the chain contains several summits which are upwards of 11,000 feet. Towards the north, the mountains decline in height as they approach the waters of the Polar Sea.

13. There are several available passes across the Rocky Mountains within that portion of the chain which traverses British territory—that is, to the north of the 49th parallel. The most important of these is the Yellow Head pass (lat. 53°), the crest of which is less than four thousand feet above the sea, while the adjacent mountains on the north side of the pass rise to nearly sixteen thousand feet. This pass, which is a thousand feet lower than any other known pass over the mountain-system, promises to become of high importance in connection with the gold-producing province of British Columbia, to which it forms the most available means of access from the eastward. The passes that traverse the chain within the territory of the United States lie at an altitude of 7,000 feet.

1 The terminal tepetl, found in the names of so many of the Mexican mountains, is, in the Aztec tongue (the native language of the Mexican Indians), a generic term applied to such mountain cones. Thus Popoca-tepetl signifies smoking-mountain (in allusion to its volcanic character); Citlal-tepetl, star-mountain; and Naucaampa-tepetl, rectangular or cubic-mountain.
THE HIGHLANDS OF THE NEW WORLD.

and upwards—an elevation at which they are blocked up with snow during a lengthened period of each year.

14. Although situated, on the whole, towards the western side of the North American continent, the Rocky Mountains are yet from four to six hundred miles distant from the waters of the Pacific. The intervening space is filled by a succession of highlands, the most remarkable of which is the territory of Utah—the home of the Mormon community. This singular tract of country constitutes a region which is physically distinct from all the adjacent territories—shut in on every side by mountain-chains, and watered by a system of inland drainage, like some of the interior plateaux of Asia. The Great Salt Lake—on the shore of which the chief city of the Mormon population is built—has no outlet to the sea, though lying at an elevation of 4,200 feet. On its western side, the plateau of Utah is bounded by the chain of the Sierra Nevada, which divides it from the auriferous basin of the river Sacramento, and the State of California.

15. The highlands which adjoin the western or seaward slope of the Rocky Mountains terminate towards the Pacific in detached mountain-chains, and elevated masses, through which the rivers that belong to the Pacific drainage of the continent pass on their way to the ocean, forming numerous falls as they break through the gorges of the mountain-region.

16. The Alleghany System.—This system consists of a series of highlands—not a mere mountain chain. It includes several narrow and parallel ridges—all of them running in the same general direction (that is, north-east and south-west), and divided by longitudinal valleys. The number of ridges varies from six to as many as twelve, the width of the whole mountain-region exceeding a hundred miles. The rivers which originate among these chains form numerous waterfalls in their passage from the high grounds into the plains below, often forcing their way through ravines of striking beauty.

17. The central axis of the Alleghany Mountains, throughout their length, is composed of gneiss and other primary rocks, flanked, over an extensive area of the mountain-region, by limestones of the carboniferous period. It is here, extending through the western division of Pennsylvania and Virginia, and into the adjoining States of Ohio, Kentucky, and Tennessee, that the most extensive of the great coal-fields of the United States is situated—a coal-field which, though it embraces an area of 14,000 square miles, is yet less than a fourth part of the total area of the coal-fields that are comprehended within the territory of the great republic.

18. The Parime System.—This system comprises several ranges traversing the plateau which rises between the low plains of the Orinoco on the north, and the Amazon on the south. The main chain extends from the Casiquiare (a remarkable stream connecting the Orinoco basin with that of the Amazon) eastwards to the coast, near the mouth of the Amazon, and is known as the Parime Mountains in the west, and the Sierra Acaрай in the east. The average elevation of these ranges is probably 4,000 feet, or about 2,000 feet higher than the plateau which they traverse. Impenetrable forests clothe the slopes of the higher ranges, and numerous rivers descend to the low-lying plains on either side
by a series of magnificent rapids and cataracts. In Guiana the descent to the coast plain is marked by a series of terraces edged by minor hill-ranges, as in the southern extremity of Africa. Geologically, the system has been well described as "a primary island rising from the vast tertiary and recent expanses of the Orinoco and Amazon."

19. The Brazilian System.—This system consists of numerous chains, some of which lie near the coast, others at a considerable distance inland. The coast-ranges are the loftiest portion of the system; the highest points, however, seldom exceed 5,000 feet. The northern portion of the coast chain, the Sierra Espinhaço, trends south (at a distance of about 250 miles inland) from the 10th to the 23rd parallel. The southern section consists of the Sierra do Mar, which closely adjoins the coast, and rises in the peculiar Sierra dos Orgãos, behind the picturesque Bay of Rio, to a height of 7,700 feet, or nearly 4,000 feet above the general elevation of the system. West of the San Francisco, a series of ridges—the Sierra dos Irmãos, Cordillera Grande, &c.—run north, between the various river-valleys from the main axial range; the Sierra dos Vertentes, an irregular and low chain of heights, between the basins of the lower Amazon and those of the Paraguay and Parana. The seaward sides of the coast-ranges are steep and rugged—the ranges traversing the interior plateau have a more gentle ascent. The mineral wealth of the system is, at present, practically inferior to the inexhaustible treasures of the forests which clothe the slopes, and even the summits, of nearly all its ranges.

EXAMINATION QUESTIONS.

1. Name the principal plateaux of the New World, and point to their places on the map.

2. What differences of climate are exhibited within various portions of these plateau-lands?

3. Name the mountain-systems of the New World.

4. What ranges are included in the Western System?

5. Give some account of the Andes, as to extent and direction.

6. What consequences to the commercial intercourse between the countries on their opposite sides ensue from the great height and continuity of the Andes?

7. The Andes coincide with a great line of subterranean heat: within what portions of the mountain-region are the results of this most strikingly manifested, and in what form?

8. What is the general character of the mountain-region within the narrower portion of the New World—i.e., Mexico and Central America?

9. Name the two highest amongst the volcanic cones of the Mexican table-land. Explain the meaning of the terminal (tepēl) found in the names of several amongst the mountains of this region.

10. Give some account of the Rocky Mountains.

11. What kind of country lies between the Rocky Mountains and the Pacific Ocean?


13. Describe briefly the Parime System.

14. What are the general features of the Brazilian System?
VI.

LOWLAND-PLAINS.

1. The plateaux and mountain-regions of the globe occupy a large portion of its surface—perhaps more than half of the whole extent of the land—and their influence over its climate and other natural conditions affecting mankind is very great. The highlands of the Old World—fitted by their physical attributes to be the home of pastoral and nomad races—were among the regions earliest occupied by mankind. From the banks of the Euphrates and the primeval cities of the Assyrian plain, the course of the shepherd-warrior—whether directed to the east or the west—led towards some of the elevated regions which stretched thence within the same (or nearly the same) degrees of latitude, and which, at least in a general sense, are under like conditions of climate. The highlands of Persia and Afghanistan, in the one direction, of Syria and the Lesser Asia, in the other, display abundant evidence, both in traditional and monumental records, of their early occupation by man. From the one, the natural order of advance leads to the fertile plains of India; from the other, to the shores of the Mediterranean, whence is easy transit to the peninsulas and islands that lie beyond.

2. But if the highlands of the earth were early the dwelling-place of the shepherd-warrior, it was within the adjoining lowland-plains and fertile river-basins that the arts of civilisation were first called into being, that towns were built, that population became numerous, and that systems of social polity were developed. The lowland-plains of Asia and Europe constitute, in the present day, the most populous regions of the globe, and include by far the more numerous portion of the human race. The like regions in the New World are fast filling with inhabitants, as the redundant population of older lands is directed, in an ever-flowing stream, across the waters of the Atlantic.

1 Gen. x. 10-12.
3. The most important and extensive amongst the lowland-plains of the Old World are the following:—

In Asia.—Plain of the Euphrates and Tigris (the ancient Mesopotamia and Babylonia); Plain of Hindustan, or Northern India; Plain of China, embracing the north-east part of that country; Plain of Siberia; Plain of Turkestan. Among lowland-regions of less importance are the plains of Pegu, Siam, and Tonquin, all within the Indo-Chinese peninsula, or India beyond the Ganges.

In Europe.—The Great Eastern Plain, embracing nearly the whole of Russia; Plain of Hungary embracing the middle portion of the valley of the Danube; Plain of Wallachia and Bulgaria, or the Lower Danube; Plain of Lombardy, or Northern Italy; Plain of Languedoc, in the south of France; Plain of Andalusia, in the south of Spain; Plain of Bohemia, or basin of the Upper Elbe.

4. The limits and direction of these regions may be traced upon any ordinary map, by means of their coincidence with the great river-basins of the eastern hemisphere. They include the longer slopes of the land, which, as pointed out in a previous chapter, are directed towards the north and north-west, as well as the less extensive low grounds which border the Indian and Pacific Oceans. The Siberian plain alone comprehends an area equal to that of Europe, and the rivers by which it is watered are among the most considerable in the Old World. So vast an area, under other conditions of climate, might have become the home of populous nations, the seat of civilisation and empire. But its high latitudes, which involve the rigour of an arctic sky, condemn a large portion of Siberia to the condition of a sterile wilderness, and must prevent even its more favoured districts from being other than thinly inhabited. The dreary swamps and morasses of the tundras, which replace, during the brief summer of those latitudes, the plain of ice and snow, stretch along the shores of the Arctic Sea through a vast extent of this wide-spread region.

5. Conditions hardly more favourable belong to the extreme northern portion of the great plain of Europe, the slope of which is directed towards the White Sea and the Arctic basin. But a large portion of Eastern Europe is inclined towards a southerly sky, and is watered by rivers which have their outfall into the Black and Caspian Seas. The Volga, the longest of European rivers, belongs to the Caspian basin, the most depressed portion of the entire region.
6. The Steppes.—The south-eastern division of the European lowland, and the adjacent portions of Asia, constitute the region of the steppes. These occupy an immense portion of the empire of Russia, and are among the most characteristic of the physical features of the Old World.

7. The steppes are grassy plains—prairies, or meadows, they would be called in the New World—which occupy a vast belt of the European and Asiatic continents. They stretch eastward from the banks of the Dnieper, far into the heart of Asia—along the shores of the Caspian and Aral Seas, and as far as the banks of the great river Obi. Indeed, in so far as their grassy covering, and general level expanse—among the prime characteristics of the steppe-land—are concerned, a like region may be said to extend to the eastward through Central Asia, as far as the Great Wall of China, and the valley of the Amur. This is the "land of grass" of the Mongol shepherd, the true home of the Tartar nations, whose descendants yet preserve in their songs the memory of their famous leader Timur—the Tamarlene of historic record. So vast is the extent of this grass-covered region, that a mounted horseman, it has been said, setting out from one of its extremities at the beginning of the year, and travelling day and night at his utmost speed, would find the season of spring elapse ere he reached its further limits.

8. The south-western portion only of the steppe-land falls within the limits of Europe. This exhibits an unbroken expanse of level plain—fatiguing to the eye from its perfect uniformity—dry and burnt up by excessive heat in summer, a pathless expanse of snow during the opposite season of the year. The steppe is only productive during the brief time that the thirsty soil is refreshed by the rains of spring and early summer. Its aspect is then, for a time, glowing and verdant; grass and wild flowers cover the earth with a carpet of varied and attractive hues, and the wild cattle and horses luxuriate in the abundant pasture. In the autumn, when the herbage has become dry and withered, the steppe sometimes exhibits a vast sheet of rolling flame, the grass being occasionally fired by accident, at other times intentionally, for the sake of the young crop which springs up through the ashes. The illusive phenomena of mirage—the result of atmospheric refraction, engendered by the intense dryness of the air—are of frequent occurrence in the steppe. Sometimes the eye is cheated by the semblance of a lake, which vanishes on approach. In other instances, the traveller over these wild regions appears to see rising before him, and glittering through the dense mist which often prevails during the hours of mid-day heat, the towers and other buildings of a distant city. Spires, trees, bridges, rivers, all appear in picturesque combination, only to sink into confusion as they are approached. When the spot where the city of enchantment had seemed to stand is actually reached, there is found only the long dry grass, waving as elsewhere in the surrounding waste. The vast accumulation of dry sand on the surface gives rise to another phenomenon, of frequent occurrence on the steppe, resembling water-spouts upon the sea, excepting that the column is filled with dust instead of water. "Suppose the great flat steppe stretched out beneath the blue sky—nothing visible—no breath of air apparently stirring
—the whole plain an embodiment of sultriness, silence, and calmness—when gradually rise in the distance six or eight columns of dust, like inverted cones, two or three hundred feet high, gliding and gliding along the plain in solemn company: they approach, they pass, and vanish again in the distance, like huge genii on some preternatural errand."

[Such is the region over which the semi-nomad tribes of Tartar shepherds, who constitute a fraction of the vast population of the Russian empire, pasture their herds. It is only here, within the limits of Europe, that the camel is successfully reared. Odessa, the great out-port of Southern Russia, stands almost on the edge of the steppe, and the whirlwinds of dust that pass through its streets, and constitute, during a portion of the year, one of its chief drawbacks as a place of residence, furnish obvious evidence of this proximity. The steppe includes two-thirds of the Crimean peninsula, the extreme south of which, however, is traversed by a hill-range of considerable elevation, and exhibits widely different features.]

9. The Khirghiz Steppes.—Beyond the Dnieper, the Don, and even the Volga, the same region of alternate grassy plain and sandy waste stretches far into the Asiatic continent. To the east and north of the Caspian and the Aral are the steppes over which roam the hordes of the Khirghiz. The names of Kara-kum and Kizil-kum,¹ given respectively to the sandy wastes which extend upon either side of the river Syr, or Jaxartes, are strikingly indicative of the general character of the tracts to which they are applied.

[Mr. T. W. Atkinson, in his "Travels in Regions on the Upper and Lower Amur," thus describes the journey through these wild regions. "For many miles the sand was hard, like a floor, over which we pushed on at a rapid pace. After this we found it soft in places, and raised into thousands of little mounds by the wind. Our horses were now changed, and in an hour these mounds were passed, when we were again on a good surface, riding hard. . . . Hour after hour went by, and our steeds had been changed a second time. . . . In our route there was no change visible—it was still the same plain; there was not so much as a cloud floating in the air, that, by casting a shadow over the steppe, could give a slight variation to the scene. . . . The whole horizon was swept with my glass, but neither man, animal, nor bird, could be seen. . . . We rode on for several hours, but there was no change of scene. One spot was so like another that we seemed to make no progress. . . . No landmark was visible, no rock protruded through the sterile soil; neither thorny shrub nor flowering plant appeared, to indicate the approach to a habitable region; all around was 'kizil-kum' (red sand)."

The perfect solitude and unbroken silence of the desert are not less characteristic than its wearisome monotony of surface. No sound of bird or animal breaks the solemn stillness which reigns around; no trees expose their foliage to the influence of the wind. The course of the traveller is still onward, through the same apparently interminable waste. "Fourteen hours had

¹ Kara-kum, black sand; kizil-kum, red sand.
passed, and still a desert was before us. The sun was just sinking below the horizon. The Kirghiz assured me that two hours more would take us to pastures and to water. . . . It had now become quite dark, and the stars were shining brilliantly in the deep blue vault. My guides altered their course, going more to the south. On inquiring why they made this change, one of them pointed to a star, intimating that by that they must direct their course.

"We travelled onwards, sometimes glancing at the planets above, and then anxiously scanning the gloom around, in the hope of discovering the fire of some dwelling that would furnish food and water for our animals. Having ridden on in this manner for many miles, one of our men stopped suddenly, sprang from his horse, and discovered that we had reached vegetation. The horses became more lively, and increased their speed, by which the Kirghiz knew that water was not far off. In less than half an hour they plunged with us into a stream, and eagerly began to quench their terrible thirst, after their long and toilsome journey."]

10. The features above described are those of the steppe region, regarded as a whole. But this aspect undergoes considerable variation in particular localities. The Lower Steppes, as those portions of the great plains which immediately border the Caspian are termed, exhibit a soil largely impregnated with saline particles, and contain numerous salt-water lakes. Some of these lakes furnish a large quantity of salt, derived by means of evaporation. This region resembles in aspect the dried-up bed of a sea. The Caspian, upon which it borders, occupies the lowest part of a depression below the general level of the earth's surface, its waters being 81 feet lower than those of the Black Sea. The extent of the Caspian appears to be gradually diminishing.

11. The features of the steppe-land, however, are exceptional to the general characteristics of the European plain, regarded as a whole. Large portions of its middle and western divisions possess a rich arable soil, and exhibit annually a waving sea of corn. The geographical limits of the lowland region are marked, in the direction of north and south, by the Black Sea and the Arctic Ocean. The eastwardly portions of this vast level expanse stretch into the heart of Asia. In the west it reaches the shores of the Baltic, and is thence prolonged, with narrower dimensions, through Northern Germany and the low flats of Holland, until it subsides beneath the waters of the German Ocean. Throughout this vast extent, tertiary and recent formations prevail, and the abundant clays, sands, and gravels, give their character to the surface-soil. The plain lying to the south of the Baltic consists principally of sandy heaths, and contains, towards the sea-shore, a vast number of small lakes or *meers*.
12. Plains of Holland.—The low shores of Holland—conquered from the sea by the persevering industry of the Dutch nation—furnish a conspicuous example of the sand-hills, or dunes, which are often found on low sandy coasts, and which owe their origin to the action of prevailing winds upon the loose drift-sand. Where no means are adopted to fix them to the soil, the sand-hills become agents of destruction, sometimes overwhelming whole villages in their slow but steady advance inland. But this is not the case in Holland, where the ingenuity of the Dutch has converted them from instruments of destruction into a means of national preservation. In some of the provinces of the Netherlands, a large portion of the land is actually lower than the level of high-water mark, and is therefore exposed (it might appear) to the ravages of the adjoining ocean. But from the channel of the Helder southward, the coast is protected by a line of broad dunes, or sand-hills, which are partially covered with grass or heath, and are in some places from forty to fifty feet in height. These have been formed by the natural process above adverted to, and still in operation: the prevalent sea-winds raise banks or ridges of sand at a short distance from the coast, which the inhabitants prevent from proceeding further inland by sowing them with a kind of grass, (arundo arenaria), the long roots of which bind the whole mass firmly together.

13. The Landes.—The district of the Landes, in the south-west corner of France, offers an example of the combined action of sand and sea which is widely different from the above in its results. The coast here exhibits a line of shifting sand, backed towards the interior by a belt of pine-forest. For a length of nearly two hundred miles, from the mouth of the Garonne to that of the Adour, there stretches along the extreme edge of the sea a range of hills composed of white sand, as fine as though it had been sifted for an hour-glass. Every gale changes the shape of these rolling masses of drift-sand. A strong wind from the land flings millions of tons of sand per hour into the sea, to be again washed up by the surf, flung upon the beach, and with the first Biscay gale blown in whirlwinds inland. A water hurricane from the west has been known to fill up with sand many square miles of shallow lake, driving the displaced waters inland, dispersing them amongst the pine-woods, flooding and frequently destroying the scattered hamlets of the people, and burying for ever their fields of millet and rye. The shepherds of the Landes pursue their avocation mounted upon stilts, which raise them above the reach of the sand-blasts. The pine-forests yield annually a large supply of resin, the only harvest of this wild region. Intermixed with the pine-forests, a chain of shallow and marshy lakes stretches in a direction parallel to the coast, and at a few miles inland.

14. Lowlands of the New World.—The lowland-plains of the New World are on a scale of vast magnitude, and, if not superior in extent to those of the eastern hemisphere, yet bear a much larger proportion to the entire area of the land. They are watered, moreover, by the longest rivers of the globe, and enjoy, for the most part, conditions of situation and climate in the highest degree favourable to man. Both in North and South America, the whole central ex-
panse of the continent exhibits a vast succession of lowland-planes, the only division between the different portions of which is that formed by the watersheds of its longer rivers—not always to be traced without difficulty, owing to the generally level nature of the entire plain. In North America, the prairies; in South America, the tracts known as llanos, selvas, and pampas, are included within the lowland region, and exhibit some of the most characteristic among the aspects of nature in the western world.

15. The Prairies.—The prairies coincide, in a general sense, with the middle and upper portion of the Mississippi valley, embracing the vast region which extends from the great lakes to the base of the Rocky Mountains. They are covered in their natural state with a rich herbage, and exhibit a waving sea of grass several feet high. At intervals, towards the banks of the rivers, patches of forest vegetation break the uniformity of the prospect, but the prairie itself is destitute of trees, and (as the name implies) is merely a grassy plain, or meadow. Alternate forest and prairie constitute the great features of natural scenery in the New World. When the rich soil of the prairie-land is broken up by the plough—an operation which is rapidly progressing, year by year, within the western states of America—it yields abundant crops of corn. There are, however, within the vast extent of the North American continent, immense regions which yet retain the aspect of the wilderness. It is within these regions that the buffalo roams, in vast herds, and that the native Indian hunter pursued his game ere the advancing footsteps of the white man had driven him from his haunts.

16. The Llanos.—The llanos, or savannahs, are vast grassy plains, which occupy nearly the whole basin of the Orinoco river, excepting only towards its highest portion, when they are succeeded by wooded plains. The llanos resemble in general features the prairies of the Mississippi valley, but have for the most part a lower level, and (owing to the abundant rains of the torrid zone) are annually inundated by the rivers to an immense extent. Whole districts, embracing thousands of square miles, are annually converted, within the interior plains of South America, into lakes, or temporary seas of fresh water, to be rapidly evaporated under the burning rays of a vertical sun. At the close of the rainy season the llanos are covered with grass, and form rich natural pasture-grounds. During the prolonged season of drought which ensues, the verdure is entirely destroyed, and the parched earth opens in wide and deep crevices—again to be laid under water with the recommencement of the rains.

17. The Selvas.—The selvas, or forest-planes, belong to the valley of the Amazon, and include an immense area of Brazil, watered by the lower portion of the great stream, and its chief tributary, the Madera. Vast regions are here covered by an uninterrupted forest, composed of trees of giant growth, their boughs interlaced by immense creeping plants, and the ground beneath thickly covered with a dense growth of underwood. To the southward of the forest region are vast grassy plains, which stretch in that direction into the valley of the Paraguay.
18. The Pampas.—The pampas, or plains of the Paraguay and Paraná valleys, exhibit the same luxuriant natural growth of herbaceous plants as other lowland regions of the New World. They include an immense region, which stretches from the neighbourhood of the southern tropic far to the southward of the river Negro (lat. 39° S.), and from the banks of the Paraná to the eastern base of the Andes. The pampas are variously covered with long coarse grass, mixed with wild oats, clover, and other herbage. The tract of country known by the name of El Gran Chaco, immediately to the westward of the upper Paraguay, —scarcely tenanted excepting by wild beasts,—exhibits a luxuriant covering of grass, which springs from a soil possessed of the highest natural capabilities.

[Further south, the plains that extend from Buenos Ayres to the foot of the Andes are covered, during great part of the year, with gigantic thistles, which grow to the height of seven or eight feet, and are so thick as to render the country almost impassable. For nine months of the year the thistles are here the predominant (and almost the sole) feature of the vegetable kingdom; but with the heats of summer they are burnt up, and their tall leafless stems are levelled to the ground by the powerful blast of the pampero, or south-west wind, which blows from the snowy ranges of the Andes, after which the ground is covered for a brief season with herbage. This is destined, with the returning spring, again to give place to the stronger vegetation which it had succeeded, and for a time supplanted.]

Examination Questions.

1. What is meant by a lowland-plain? What influence have lowland-plains and river-basins exerted over the social advancement of mankind?
2. Enumerate the principal lowlands of Asia, and point out their places on the map.
3. Name the principal plains of Europe, and point to their places on the map.
4. With what river-basins do the following respectively coincide:—plain of Hungary:—plain of Northern India:—plain of Lombardy:—plain of Andalusia:—plain of Bohemia?
5. What are steppes, and in what part of the Old World are they found? Give some account of their appearance.
6. To what portions of the steppe-region do the names of "Kizil-kum" and "Kara-kum" apply? State the meaning of those terms.
7. Over what portions of the European continent does the great plain extend?
8. What are dunes? To what natural cause is their origin due, and in what way do the people of the Netherlands make them serviceable in the protection of their land?
9. Where are the Landes, and what is their general aspect?
10. By what names are portions of the great lowland-plains of the New World respectively distinguished?
11. Give some account of the prairies, and point on the map to the prairie-region. With what river-basin does this region coincide?
12. Describe respectively the region known as llanos (or savannahs), and say what river flows through this region.
13. What is the aspect of the selvas, or forest-plains, and in what river-basin are they found?
14. Where are the pampas? Give some account of them.
VII.

THE OCEAN.

1. The Ocean\(^1\) covers nearly three-fourths of the surface of the globe. It is one vast and continuous fluid surrounding and insulating the land. The great continental masses which constitute the Old and New Worlds become but vast islands when viewed in reference to the entire surface of the globe.

2. Divisions.—The waters of the ocean are divided by the land into three great basins, to which the names of Atlantic, Pacific, and Indian, are applied. These divisions are distinctly marked out upon the Map of the World. The Atlantic Ocean lies between the coasts of Europe and Africa upon the one side, and those of America upon the other. The Pacific Ocean divides the western shores of the New World from the eastern coasts of Asia and Australia. The Indian Ocean lies to the southward of the Asiatic continent, and is limited by Africa and Australia in the direction of east and west. Besides these two other oceans are usually distinguished, viz., the Arctic, and Antarctic Oceans. The Arctic Ocean is enclosed for the most part by the northern coasts of Europe, Asia, and North America, but, between the shores of Greenland and Norway, a distance under the Arctic circle of nearly 1,400 miles, it is open to the expanse of the Atlantic, with which, indeed, it is there continuous. The Antarctic Ocean is the name given to that portion of the sea comprised within the south polar circle. This ocean has no definite natural limits; its waters merging indefinitely into the great Southern Ocean\(^2\)—a term applied by geographers to that vast belt of water which extends, with comparatively little interruption from land round the globe, between the parallel of 35° south and the Antarctic circle.

\(^1\) Greek, Okeanos.

\(^2\) Strictly speaking, this term is inadmissible, as the Pacific, Atlantic, and Indian Oceans are supposed to be continued south until they meet the Antarctic Circle. Practically, however, the term is appropriate, for neither of the three great oceans have any defined natural limit to the southward. In treating of oceanic circulation, and the tides also, the term is most convenient, as denoting accurately the area in which the great movements of the ocean originate.
3. Every circumstance connected with the great ocean—its varying depths, the composition and chemical properties of its waters, their colour, density, temperature, movements, and other phenomena, with the forms of life of which they are the seat—constitutes a topic of interest to the physical geographer, and has formed a subject of scientific inquiry. The physical geography of the sea forms, indeed, a necessary supplement to the physical geography of the land, and it is only by a combined study of the two that we can attain an adequate conception of the natural condition of the globe's surface, and of its varied influences upon the destinies of man.

4. Depth.—The depth of the sea has formed within recent years a subject of earnest inquiry. The practical requirements of the navigator have at all times made it necessary to know the depth of water at the mouths of rivers, the entrances of harbours, and in the immediate neighbourhood of shores frequented by shipping. Hence the elaborate charts that are issued by the Boards of Admiralty of our own and other nations, and upon which are marked the results of detailed surveys, in which the sounding-line has been the most important instrument of observation. In shallow seas, such as the German Ocean or the Baltic, where numerous sand-banks rise above the general level of the bottom, and in many cases even reach the surface at low water, a knowledge of the exact depths is indispensable to the mariner. The sounding-line and the chart furnish the only safe means by which he can guide his vessel through their waters. This is more particularly the case during the frequent prevalence of dense fogs, by which these and other parts of the ocean—the Gulf of St. Lawrence, for example—are often covered. The agency of violent storms, and the yet more powerful action of currents, produce frequent changes in the sand-banks deposited upon the ocean's bed, and necessitate the frequent renewal of observations on their extent, with the depth of intervening channels and other conditions.

5. The attainment of deep-sea soundings has within a recent period assumed an equally practical character, in connexion with the laying of submarine cables to connect the telegraphic stations now so generally distributed over the land. The narrow seas which divide Britain from the shores of the continent, the waters of the Mediterranean, the Persian Gulf, and the adjoining portions of the Indian Ocean, are crossed by the wires of the submarine telegraph, and even the bed of the Atlantic is similarly traversed. Such achievements, to be made with any fair prospect of tangible result,
require the possession of a vast number of observations upon the depth and character of the ocean’s bed along the proposed line of route.

6. Further, a knowledge of the bed of the sea is necessary to the possession of a true idea of the physical geography of the globe. The reliefs of the land are continued below the surface of the waters. The mountain-chain—invisible for a time where its slopes sink below the Atlantic or the Pacific waves—reappears in the island-groups of the deep. A knowledge of the constituent particles which are drawn up, by the aid of the sounding-line, from the bottom of the sea, supplies the scientific observer with information of high value as to direction of currents and other conditions of the aqueous portion of the globe, and reveals, besides, much that is of interest in connection with the geological changes which our planet has in former ages undergone, and the forms of life of which it has, at some former epoch, been the seat.

7. Such observations, especially those made within recent years completely dispel the idea that the sea-bed presents inequalities corresponding to those that diversify the surface of the land. A careful analysis of the most recent researches prove conclusively that the sea-bottom does not, except in a few isolated instances, where the normal regularity of the ocean-floor has been broken by violent volcanic disturbances, present the abrupt descents and extreme inequalities so common on the land, but is, on the whole, gently undulating. The floor of the ocean is therefore far more regular than the surface of the land; and, from the results already obtained in different parts of the great oceans, it does not seem probable that there are many “precipices” or “walls” in the ocean, except in certain coralline or volcanic areas. Such a “precipice” was formerly thought to exist at a distance of about 180 miles west of the Irish coast, where the “Telegraphic Plateau” commences. But, as Professor Huxley remarks, the true inclination, even here, is not more than 1 in 25, or that of a hill of moderate steepness; so that, if it were a mere question of gradients, a waggon could be driven along the sea-bottom from Ireland to Newfoundland without any difficulty.¹

¹ Physiography, p. 63. (London: Macmillan).
exaggerated, so that what looks in the section almost a perpendicular descent, is in reality a gentle slope. This is indeed unavoidable, except in sections of very small areas; in all other cases the horizontal dimensions are so much in excess of the vertical, that the two could not be conveniently shewn in their actual relation. Thus a section of a basin 700 miles across, with a maximum depth of 2,850 fathoms shown by a vertical line 3½ inches high, would be upwards of 50 feet wide.]

8. Our knowledge of the depths of the great oceans has been considerably increased of late years by the labours of the American navy, the soundings carried on by the Lightning and the Porcupine, and more especially the results obtained by the voyage of the Challenger. In the course of its long cruise the Challenger fixed upon certain stations, where the depth of the ocean was carefully sounded, the temperature of the water taken at various depths, and the natural history of the locality ascertained by means of the trawl and dredge. There were 150 such stations in the Atlantic, and 100 in the Pacific. From these soundings it appears that the average depth of the ocean is between 2,000 and 2,500 fathoms. The greatest depth recorded was found in the Pacific, north of New Guinea (in lat. 11° 24' N., long. 143° 16' E.), where the sounding line indicated a depth of 4,575 fathoms, or about 5¼ miles. In the Indian Ocean, the greatest depth observed was 2,254 fathoms; and in the Atlantic, 3,875 fathoms. As regards the Polar Seas, no depths exceeding 2,000 fathoms have hitherto been observed north and south of the parallels of 60° N. and 60° S. lat., and the average depth of both polar basins is most probably much less.

9. The formerly general notions of "unfathomable" depths of the ocean are thus entirely disproved. By far the greater number of soundings taken in the open ocean do not exceed 2,500 fathoms, or 15,000 feet, while the greatest depth yet observed falls short of the highest elevation on land by about 1,400 feet. Careful analysis of the results of recent researches proves conclusively that depths of five miles, or over 4,000 fathoms, are but seldom met with, and are as exceptional as heights of the same amount on land.

10. We may also notice that the depth of the ocean has also been theoretically determined by observations on waves, and that the results thus obtained in

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1 This vessel, carrying a staff of naval surveyors and a body of scientific naturalists, left Portsmouth in December 1872, and returned to England in May 1876. It crossed the Atlantic four times, and reached Cape Town towards the close of 1873. Leaving the Cape after a short stay, it visited Kerguelen Island, and advanced for some distance within the Antarctic Circle. It then successively visited Melbourne, Sydney, New Zealand, and the Fiji Islands. Hence passing through Torres Straits and the Malay Archipelago, it arrived at Hong-Kong. Sir George Nares, who had hitherto been in command of the Challenger, was here recalled to take charge of the Arctic Expedition; and the vessel, under the command of Captain Thomson, now visited the Philippine Islands, New Guinea, Japan, the Sandwich Islands, and Tahiti, whence it proceeded to Valparaiso. The vessel left Valparaiso in December 1875, and returned home by way of Magellan's Strait and the Atlantic.

2 It should be observed that the U.S.S. Tuscarora obtained deeper soundings in the Pacific, off Japan—the deepest amounting to 4,600 fathoms.

3 The German frigate Gazelle took two reliable soundings of 3,920 and 3,010 fathoms respectively, in the deep basin between Java and Australia.

4 Thalassa (J. J. Wild).
some instances approximate those obtained by actual sounding. The "theory of waves" is based on the relation between the breadth and velocity of a wave, and the depth of the water over which it travels. Given, therefore, the breadth and velocity of a wave, the depth of the water may be approximately determined.

II. Sounding.—The ordinary method of ascertaining the depth of the sea is by "sounding" with a line to which a weight is attached. In shallow or even moderately deep water this method answers very well, as the observer can nearly always determine when the weight strikes the bottom, the check on the extreme tension of the line being distinctly felt. But when tried in deep water this method is useless—the results being always greatly exaggerated. When the weight strikes the bottom can only be guessed, for the line never ceases to run out. Hence the enormous depths reported by the early explorers—40,000 and 50,000 feet without apparently touching the bottom. Subsequent improvements in the method of sounding proved that, after the weight had touched the bottom, the line would still run out, being more or less deflected by under-currents. It was therefore necessary to ascertain when the weight struck the bottom. After repeated experiments, what is known as the "law of descent" was discovered. This law proved (1) that the line did not run out at a uniform rate, but sank slower and slower as the depth increased, and (2) that the moment the weight rested on the bottom, under-currents commenced to deflect the line, and caused it to run out at a uniform rate. It was therefore easy to determine when the weight touched the bottom by noticing the rate at which the line ran out. As yet no "sample" of the bottom of the deep sea had been obtained—the heavy weights used in deep sea sounding could not be drawn up again. Lieutenant Brooke, of the United States Navy, contrived a simple but most effective apparatus, by which the weight or "sinker," on striking the bottom, was detached, leaving only a light tube to be drawn up, bringing with it a small quantity of the material at the bottom. The apparatus employed by the Challenger and other deep-sea expeditions were constructed on the same principle—the disengagement of the weight from the line on touching the bottom.

But probably the most ingenious and perfect sounding apparatus yet invented is that of Sir William Thomson, which is designed for the purpose of ascertaining, accurately and quickly, the depth of water under a ship, without stopping or even reducing her speed. The principle on which the apparatus is based is the determination of the actual pressure of the superincumbent column of water at a given point, and thus find the actual depths. This is done by attaching to the line a brass tube, in which a glass tube, coated inside with chromate of silver, and closed at one end, is placed with its open end down. As the sinker descends, the increased pressure drives the sea water up the glass tube, which, combining with the chromate of silver, makes a white mark, which shows the height to which the water has been forced up the tube, or in other words, the pressure. The tube is compared with a graduated scale which shows at once the exact depth to which it has been. This method is entirely independent of the length of line run out, so that it is not necessary to stop the vessel to take a sounding.

1 Formulated by Sir G. Airy, the Astronomer-Royal.
12. **Temperature.**—The temperature of the sea undergoes much less variation than that of the land. Excepting in very high latitudes, it falls with increase of depth. Beyond the Polar circles, however (and, perhaps, in some cases, before they are reached), the surface-water is generally colder than the deep sea, and the temperature rises with the depth. Neither the increase nor the decrease, however, exhibits any uniform ratio, and recent observations have shown conclusively the fallacy of the theory once entertained respecting a supposed minimum temperature of $39\frac{1}{2}$° F. The observed temperature at various depths is no doubt often influenced by the currents from colder or warmer latitudes respectively. In the equatorial part of the Atlantic the surface temperature ranges from 80° to 83° F., while further north, towards the Arctic, it falls to 54°—44° F. In the North Pacific the mean surface temperature is about 70° F.; and in the South Pacific about 67° F. The general bottom-temperature in North Atlantic is 35°3° F., and the South Atlantic 32°9°, or nearly 3° colder. In the North Pacific the bottom-temperature is generally below 35° F.; in the South Pacific it falls to 32°5° F. off Cape Otway; and still further south, the entire mass of the water, from a depth of 1,000 fathoms to the bottom, had a temperature of from 32° to 31° F.

13. The lowest layer of water throughout the ocean, even under the equator, is thus nearly at, or occasionally below, the freezing point—that is, actually below the general temperature of the earth's crust. Were this cold mass immovable, surely its temperature would in time approximate that of the crust it overlies. This cold bottom-layer must, therefore, be an influx from the Polar basins—principally from the Antarctic, as the communication between this and the three great basins of the Atlantic, Indian, and Pacific Oceans is perfectly open for considerable distances, while the Arctic basin is freely open only to the Atlantic. There is thus, as we shall again notice more fully, an under-flow of the water from the Polar Seas to the Tropics, compensating the over-flow of the warm tropical waters towards the Poles.

14. It is worthy of notice that the temperature of water in enclosed basins does not, as in the open ocean, gradually decrease from the surface to the bottom, but preserves the same temperature from a certain depth (marked by the summit of the surrounding ridges) to the bottom. Thus, in the two adjacent basins of the China and Sulu Seas, the temperature of both at the surface, and at a depth of 200 fathoms, is the same, viz., 84° and 50°5° F. But in the China Sea the temperature of 50°5° F. at 200 fathoms, falls to 37° F. at the bottom, while in the Sulu Sea the temperature from 200 fathoms to the bottom (1,780 fathoms) is uniform, that is, 50°5° F. The reason is, that the waters in an enclosed basin never come in contact with water colder than that overlying them, and, therefore, must in time acquire the same temperature.

15. The most important truth concerning the temperature of the sea, however, is the fact of the little change which it undergoes throughout the year, as compared
with the land. It is to this that its most important influences upon climate are due, as we shall see in a future page. Between the hottest hour of the day, and the coldest hour of the night, the maximum difference in the temperature of the sea does not exceed four degrees.

16. Saltness.—The saltness of sea-water constitutes one of its well-known characteristics. This, as well as its intense bitterness, and great specific gravity, is due to its holding in solution various saline particles, amongst which chloride of sodium (NaCl)—that is, common salt—holds the most important place.

The following analysis of water in the English Channel is recalculated from the one given by Schweitzer in the Philosophical Magazine, vol. xv. p. 58:

<table>
<thead>
<tr>
<th>ONE HUNDRED PARTS OF WATER CONTAIN:</th>
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<tbody>
<tr>
<td>Chloride of Sodium</td>
</tr>
<tr>
<td>Chloride of Potassium</td>
</tr>
<tr>
<td>Chloride of Magnesium</td>
</tr>
<tr>
<td>Bromide of Magnesium</td>
</tr>
<tr>
<td>Sulphate of Magnesia</td>
</tr>
<tr>
<td>Sulphate of Lime</td>
</tr>
<tr>
<td>Carbonate of Lime</td>
</tr>
<tr>
<td>Iodide and Ammonia</td>
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</tbody>
</table>

17. The proportion of saline matter which the sea contains is not uniformly the same. The saline contents of the open ocean average in general from 3.5 to 4 parts in every hundred, estimated by weight. That is, in any given weight of water, a proportion of three and a half or four per cent. is composed of saline matter, which, by evaporation, becomes a solid residuum of salt. Hence the facility with which salt is obtained at many places on the sea coast, where extensive salines are formed (as upon the shores of Portugal, and on various parts of the Mediterranean coast) for the purpose of evaporation by the hot rays of the summer sun.

18. The waters of the Gulf Stream, which cover an immense area of the North Atlantic, are distinguished from other parts of the ocean by their greater saltiness, and their deeper blue; the greater intensity of colour being a consequence of the larger proportion of briny matter held in solution. The difference in quantity between the saline contents of the Bay of Biscay, and the waters of the Gulf Stream off Charlestown, in the United States, amounts to a half per cent., and the difference is still greater in the case of other portions of the same

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1 The total saline ingredients is therefore nearly 3½ per cent.—i.e. 100 lbs. of sea-water contain 264 lbs. of water, and 3½ lbs. of solid matters in solution. The total quantity of solid matter dissolved in the waters of the ocean must therefore be enormous. It is indeed estimated that it would cover an area of 7,000,000 square miles to a depth of fully one mile. According to Bischof, the total percentage of salts in sea-water is 3.527 (Chemical Geology, i. 379).
current. Near the mouths of rivers, the saltiness of the sea becomes lessened by the quantity of fresh water poured in. The current of the Amazons and the La Plata may be traced at a distance of several hundred miles away from land. The patches of floating grass, mingled with tree-trunks and withered foliage, brought down by the Amazons, are seen many hundreds of miles away from land.

19. The waters of the Mediterranean contain more salt than those of the ocean, the proportion of saline matter included within them being nearly four per cent. (16%ths) of their weight. In the Red Sea, the proportion is still greater, amounting to 18%ths. The Baltic, on the other hand, is less salt than the ocean, and its gulfs become, towards their upper extremities, almost fresh. The number of large rivers which discharge into the Baltic, together with the outward current through the straits by which it is connected with the open sea, sufficiently account for the last-named fact. In the Mediterranean, on the contrary, the volume of fresh water poured in by rivers bears but a trifling proportion to the area of its vast basin. The Nile is the only river of first-rate magnitude which discharges into it. Further, a current constantly sets into the Mediterranean through the Strait of Gibraltar. This current is constantly carrying the salt water of the Atlantic into the Mediterranean basin. Evaporation furnishes the chief (if not sole) means by which this constant influx of water is carried off, and the general equilibrium of its contents preserved. But evaporation only carries off fresh water, leaving behind the saline particles of the ocean’s contents. It is therefore probable that the saltiness of the Mediterranean may be slowly on the increase. The Red Sea offers a still more striking instance of like kind, since it does not receive a single perennial stream, while its loss from evaporation is supplied by a constant current flowing in through the Strait of Bab-el-Mandeb.¹

[There is no proof that the saline contents of the ocean undergo, on the whole, any change in their proportion. It is undoubtedly true that all so-called fresh waters contain a small quantity of the same saline particles that are found in the sea-water. The influx of rivers, and the washings occasioned by rain-fall upon the land, thus alone furnish a sufficient explanation of the present saltiness of the ocean. But although evaporation fails to carry off the continual accumulation of saline matter thus supplied to the ocean, yet there are other natural agencies at work, such as the secretions of marine insects and other inhabitants of the ocean, which preserve the general balance unaltered. This theory fully accounts for the present saltiness of the ocean, but bearing in mind the undisputable geological proofs that the sea was, as it is now, salt in the past, even in the most remote periods—it is highly probable that its waters have always been salt, even since they were condensed out of the original atmosphere of gas and

¹ According to Mr. Buchanan’s chart, showing the “Distribution of Saltiness in the Ocean” (Journal of the Royal Geographical Society, vol. xlvii.) the areas of maximum saltiness are—in the North Atlantic, between 20° and 40° W. long., on either side of the tropics of Cancer and Capricorn respectively. The areas of minimum saltiness are—the Gulf of Guinea, the North Sea, Baltic, a narrow belt along the American coast from Newfoundland to Florida, about 50° N. and S. of the equator in the Indian Ocean, between 15° and 30° N. lat. in the Pacific, and south of lat. 40° S. in the Southern Ocean.
vapour, and that they carried down the saline vapours which were no doubt at first diffused abundantly through that atmosphere. The results of the saltiness of the sea are obvious. Salt water does not evaporate or freeze so readily as fresh water. Were the sea fresh, therefore, evaporation would be much more active, and the polar frozen areas much more extensive—in fact, the whole climatic condition of the world would be changed.]

20. **Specific gravity**—The specific gravity or density of sea-water, compared with fresh water at 1, amounts to a mean of 1.0275. Recent observations appear to show a slightly higher specific gravity in the water of the Atlantic than in that of the Pacific Ocean. In the case of both, the specific gravity becomes lessened near the mouths of large rivers, owing to the influx of fresh water. The specific gravity of the Mediterranean is greater than that of the ocean, a result due to the larger proportion of saline ingredients in its waters.

<table>
<thead>
<tr>
<th>Table showing the Mean Specific Gravity of Sea-water in—</th>
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<tbody>
<tr>
<td>North Atlantic ........................................ 1.0266</td>
</tr>
<tr>
<td>Indian Ocean ........................................... 1.0263</td>
</tr>
<tr>
<td>South Atlantic ......................................... 1.0267</td>
</tr>
<tr>
<td>Baltic .................................................. 1.0086</td>
</tr>
<tr>
<td>North Pacific .......................................... 1.0254</td>
</tr>
<tr>
<td>Mediterranean .......................................... 1.0289</td>
</tr>
<tr>
<td>South Pacific .......................................... 1.0265</td>
</tr>
<tr>
<td>Red Sea ................................................ 1.0286</td>
</tr>
</tbody>
</table>

[Generally speaking, the specific gravity of the surface-water is less than that at great depths, not only on account of the influx of fresh water, but also from the fact that water is slightly compressible, being at a depth of 1,000 feet compressed \( \frac{1}{10} \) of its bulk. The absolute pressure of the water increases, of course, uniformly with the depth, but the density does not—the density of the surface-water in some localities being in excess of that of the bottom. Thus Sir Wyville Thomson found in the North Atlantic, in 54° 28' N. lat., and 11° 44' W long., the density at the surface to be 1.028, while at the bottom (8,550 feet) it was 1.0269. Differences of temperature also cause differences in density—thus fresh water has its greatest density at 39° 2' F. Two causes, therefore, combine to produce differences in the density or specific gravity of sea-water, viz., proportion of saltiness and degree of temperature. The result of this difference is manifested in the constant movements of the entire mass of the ocean, which we shall explain in a subsequent section.

21. **Colour**.—The colour of the sea is well known, or at least by observation in the immediate neighbourhood of the land. But the pale sea-green tint which distinguishes shallow waters assumes a bluer shade with increasing depth, and far away from land, in the midst of the great ocean, becomes a deep indigo. This deeper shade of blue is connected with the increased saltiness, as well as depth. The

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1 Professor Geikie.
2 Freezing point of fresh water, 32° F.; salt water, 28° F., or even lower under certain circumstances.
waters of the Gulf Stream, off the coast of Carolina, are of a deep indigo hue, are readily distinguishable by colour alone from the water amidst which it flows. The Mediterranean is celebrated for the intense blue of its water. The Red Sea, notwithstanding its name, possesses a like distinction in the deeper portions of its mid-channel. It is only amidst the coral-reefs which border its shores on either side, that the reddish hue of its water, due to the abundance of microscopic animal life, is observable.

22. Local peculiarities in the colour of the sea are due to various causes. The muddy sediment carried down by the great rivers of the Chinese plain explains the prevailing tint which gives its name to the Yellow Sea. The alternate streaks of blue and green, which have been observed in the Greenland Seas and elsewhere, are due to abundance of minute forms of animal life.

[We may here briefly notice, also, the phosphorescence or luminosity of the sea. A recent writer thus graphically describes this beautiful phenomenon:—"We have seen it fitfully gleaming over the sleeping waters, and again gilding with burning light every wave and ripple within sight. Sometimes so pale as to seem spectral in its whiteness; sometimes glowing in a ship's wake so powerfully that books may be read by its light. At times it studs the sea like myriad water-stars, and on pouring the water through the hands the fiery points will adhere to the fingers, glowing all the while. Great globes of living fire well up from beneath the ship's keel, or irregular patches constantly changing in outline float around. Every now and then a flash of fire is propagated across the surface, and all remains dark until illuminated by another similar display." This luminous appearance, generally of a pale greenish colour, is due to the presence near the surface of vast numbers of various minute luminous animals, and is more perceptible on a dark night, when the water is perfectly calm.]

23. Movements of the Ocean.—We have already observed that the waters of the ocean contain percentage of saline matters in solution which confers upon them their characteristic saltiness. The proportion of saline matters varies from 3.5 to 4 per cent., that is, the average difference in the saltiness of sea-water throughout the ocean only amounts to 5 per cent. And this remarkable uniformity as regards saltiness is not only true of the surface-water, but also of the entire mass, from the surface to the bottom. This general uniformity is still more remarkable when we reflect upon the numerous causes which are constantly producing considerable local changes—active evaporation, excessive precipitation, &c., and yet the sea is nearly as salt under the equator as in high latitudes—the general uniformity remains unchanged. This is undoubtedly due to the incessant movements of the ocean, by which its waters are thoroughly mingled
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together, and the saline matters in solution evenly distributed throughout the entire mass of the water, horizontally from the equator to the poles, and vertically from the surface to the greatest depth. These movements of the ocean are threefold—being produced by the winds, lunar and solar attraction, and differences in temperature and density. The first species of movements are known as waves, the second constitute the phenomena of the tides, while the third form the currents of the ocean.

24. Waves.—The most frequent and universal cause of disturbance in the surface of the ocean is found in the winds. These at one time raise a mere ripple upon the waters, and under other conditions lash them into fury, generating the great waves which accompany the storm. The height of waves generated in the open ocean has been, however, greatly exaggerated, as is shown by careful observations made within recent years. Dr. Scoresby measured the height of the Atlantic waves, after a long-continued gale of the severest kind, by mounting to successive heights above the deck of the ship, until he could see over the crest of the approaching wave. He found that the mean highest waves reached a height of 43 feet above the level of the hollow occupied by the ship—the height above the mean level of the sea being, of course, only half that amount. The average height of the Atlantic waves does not exceed 24 feet from trough to crest, or half that number of feet above the mean level of the waters. The interval between the successive waves was estimated, on the same occasion, to be about 600 feet, and their rate of advance equal to 32 miles per hour. The remarks of other observers confirm these conclusions. But where the onward progress of the mass of water is restricted by any obstacle, as in a sea which dashes up against an iron-bound coast, the waves roll up to much greater height; as, under like conditions, they overtop piers or light-houses, while the almost resistless force of the watery mass frequently removes huge masses of rock. The construction of piers and light-houses has furnished instances of masses of rock weighing forty tons having been moved by the waves. It it thus that nature sports with the works of man.

[Nature of Wave-Motion.—Mr. T. W. Piper, in his admirable Text-book on “Acoustics, Light and Heat,” thus graphically illustrates the nature of wave-motion.

"To obtain a clear idea of this motion, let us take up a position by the side of a river, and watch the pieces of wood floating down with the stream to the sea. Here we have the waters of the river actually moving forward in a certain definite direction, thus providing us with an instance of the translation of
matter; for of course we regard the water particles as particles of matter. Here also we see that the translation of particles of one kind of matter may cause the translation with them of other particles of a different kind of matter, viz., solid particles of wood travelling upon liquid particles of water. Leaving the river's side we make our way now to the sea-side, and there occupy ourselves in watching the great waves rolling in towards the land. At some little distance from the beach we may notice a quantity of sea-weed dancing up and down upon the surface of the water, and if we narrowly observe it, we shall find that though it is ever in motion, now rising high upon the crest of a wave, and now sinking down into the depths of its trough, it still remains at about the same distance from us, neither advancing towards us nor receding from us. If now there was in the sea at this point a continual translation of matter, as there was in the river beside whose water we lately stood, it would be seen that the sea-weed should be carried along in a direction coinciding with that in which the water was moving; seeing, then, that the sea-weed does not change its position, we conclude that the water upon which it floats does not suffer any translation from one place to another, although it certainly is ever in motion, and although waves are most certainly continually traversing its surface.

"It may easily be shown that an up and down motion of the particles of a body would cause the translation of a wave from one point to another, which amounts to showing that a wave may be caused to move from one point to another through that body, by the vibratory motion of its particles, in a direction at right angles to that in which the wave proceeds.

"In the accompanying diagram (Fig. 9), let the rectangles aA, bB, cC, &c., represent the spaces through which the particles in these rectangles have power to move up and down, and let the circles numbered with a figure 1 represent the particles forming the surface of the wave whose crest is at p, and the lowest parts of whose depressions are at G and Y. Then it is clear that the particle
at $p$ is at the farthest limit of its excursion upwards, and that those at $G$ and $Y$ are at the farthest limit of their excursions downwards, and it is in harmony with this to suppose that the particles in the spaces $A$ to $F$ are all descending, those in the spaces $H$ to $O$ ascending, those from $Q$ to $X$ descending, while $Z$ is also ascending. Under these circumstances the surface of the wave is represented by the thick line drawn through the particles numbered 1. Let us now suppose that the particle at $p$ begins to descend, and continues to do so till it has gained the space 2 below it; by this time the particle $O$ has gained its highest position, and now forms the crest of the wave, the whole surface of which is represented by the dotted shapes numbered 2. Supposing now that the particle at $P$ continues its downward course till it rests at 3, it is clear that the crest of the wave will then be at $n$, and that the circles numbered 3 will represent the surface of the wave at this moment.

"Without giving this as an exact explanation of the manner in which a wave is actually propagated through a body, we may use it to show that there are two distinct movements to be observed in wave motion, viz., 1st, the onward motion of the wave itself (which is simply a translation of motion), and 2nd, the vibratory motion of the particles of the body through which the wave is propagated, this vibratory motion being really a translation of matter (viz., the individual particles of the body), alternately upwards and downwards through a limited space; and further, it assists us to a right conception of what a wave is, viz., that it is simply the propagation of a form or shape (and therefore does not imply a translation of matter in the direction in which it is itself propagated).

"If we apply the above conception to the water-wave, and then conceive a chip of wood (or bit of sea-weed) so extremely small as to rest on one alone of the water particles represented in the figure, say $p$, then it is clear that such chip, receiving its support solely from $p$, must rise as $p$ rises, and sink as it sinks; and being (as we suppose) subject to no other influence than that exerted upon it by the water upon which it rests, cannot do otherwise than rise and fall with the water without suffering the least translation whatever, except such as is also experienced by $p$; and since we have supposed that $p$ simply oscillates up and down in its own rectangle, it follows that the only effect of the wave upon the chip will be to cause it to dance up and down with the surface of the water upon which it rests."2

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1 For further particulars the student is referred to the text-book in *Acoustics, Light and Heat*, intended as an introduction to the study of Physical Science, by T. W. Piper, late Normal Master in St. John’s College, Battersea. London: George Philip & Son.

2 If any confusion still exist in the mind concerning the difference between the motion of the wave and that of the particles through which it travels, let the student take a round ruler, and having placed it upon a table and covered it with a cloth, press the ruler forward between the table and the cloth. Then, although the cloth does not move forwards nor backwards, to the left nor to the right, but simply rises and falls as the ruler advances beneath it, yet there is a transference of a hump, or wave, from one side of the table to the other. The ruler here represents the power to which the wave motion is due, the rise and fall of the table-cloth illustrates the oscillation of the water particles in an upward and downward direction, and the passage of the hump across the table fitly represents the passage of a wave across water.—Piper.
25. Tides.—The explanation of the tides is astronomical. They are caused by the attraction which the moon exerts over the waters of the earth. The sun exerts a like attractive influence, but in a much less degree than the moon, owing to its vastly greater distance.

26. The attraction exercised by the sun and moon over the waters of the earth is a consequence of the law of universal gravitation. This law is embodied in the axiom that "every particle in the universe attracts every other particle, with a force which bears an inverse ratio to the square of the distance"—that is, a force which increases as the square of the distance is diminished. The moon is the nearest of the heavenly bodies to the earth, and the mobile nature of water leads it to yield readily to the attractive influence. Those parts of the waters which are nearest to the moon—that is, the parts directly under the moon's vertical path in the heavens—are hence drawn out towards the moon. From precisely the same cause, and at the same time, the waters farthest away from the moon—or at the opposite side of the earth—are led to bulge out beyond the general line of the globe's circumference. The subjoined diagram shows the figure which, supposing no counteracting or modifying influences, the waters of the earth would thus assume under the moon's attraction:

![Diagram of Earth and Moon](image)

The waters at $a$ are drawn out towards the moon because that portion of the earth's surface is nearer than any other part. For the same reason, the waters at $b$, being farthest away, experience the gravitating force in the least degree, and recede farther from the attracting body than any others. The waters of the globe, therefore, culminate at the same time toward those points which are under the moon's vertical influence upon opposite sides of the earth. In doing this, they are drawn away from those parts of the globe which are 90° distant from this vertical influence—that is, from the meridians which are farthest removed from the meridian over which the moon is at any given moment vertical.

27. The tidal changes, considered as a whole, result from the above conditions, which, however, become greatly modified by the various local features of the terrestrial surface—i.e., by the irregular distribution of land and sea, and the unequal depths of the latter. The modifications thus induced in the tidal wave are of the highest
importance. According to the astronomical theory, it would uniformly be high water at the same moment upon opposite sides of the meridian over which the moon's path is situated, and low water under meridians which are 90° distant upon either side.

28. The earth's rotation on its axis occasions an apparent circuit of the moon (with all the heavenly bodies) round the earth in a direction from east to west. Every place on the earth is thus brought in succession under the direct line of the lunar influence, and passes thence to the points which are farthest removed from that influence. The conditions of high and low water hence recur twice within each successive period of the moon's return to the same meridian—that is, within twenty-four hours and fifty minutes.

29. The period of the moon's return to any given meridian, after accomplishing an apparent circuit of the globe, is greater by 50 minutes than the mean solar day (24 hours), owing to the fact of the moon's monthly circuit round the earth, performed in the same direction as the motion of the earth on its axis—that is, to the eastward. While the earth accomplishes one revolution on its axis, the moon is advancing in her orbit. The earth has hence to make rather more than a complete rotation in order to arrive at the same position, relatively to the moon, that it had on the preceding day. In other words, it takes a little more than twenty-four hours for the moon to return to its vertical place over any given meridian. Hence the interval between the successive conditions of high and low water is a little in excess of six hours, and the high and low water of any given day are later by nearly an hour than they were on the preceding day.

30. The sun's influence upon the tides is evidenced in its either increasing or diminishing the lunar tide, according as the sun's place in the heavens coincides with the line of the moon's attraction, or the reverse. A reference to the diagram on page 9 will explain this. When the sun, relatively to the moon and earth, is in either one or other of the places marked S or S', its gravitating force acts upon the waters of the earth in the same direction as that exerted by the moon. The solar influence, in either case, is added to the lunar influence, and the tidal wave which is generated is higher than would be the case under the influence of the moon alone. In the former case—that is, supposing the sun at S—the darkened side of the moon is toward the earth, and it is new moon. In the latter, the sun being at S', the moon's enlightened half is directed to the earth, and it is
full moon. When, on the other hand, the place of the moon in the heavens is $90^\circ$ distant from the sun's place—which is the case when the moon is either seven days or twenty-one days old, that is, in either her first or her last quarter—the sun's influence over the earth's waters acts in a contrary direction to the lunar influence, and tends to diminish the height of the lunar tide. It is this difference which produces what are known as spring tides and neap tides. Spring tides occur at the times of new and full moon, and are the added result of the gravitating influence of both sun and moon; neap tides occur when the moon is in her quarters, and are not so high as the spring tides, because they exhibit the lunar influence lessened by the sun's force acting in an opposite direction.

31. Direction of the Tidal Wave.—Such is the general theory of the Tides, but the actual time of high-water at any place, and the height of tide (or difference of level between high and low water), depends upon various local conditions. It is within the unbroken expanse of the Southern Ocean—where alone the waters of a deep sea extend continuously around the entire circuit of the globe—that the tidal wave is generated; and its course thence towards other parts of the sea is determined in great measure by the particular shape of the enclosing land, and the direction of the coasts, as well as the depth of the sea and the nature of its bed. Thus the tide which is experienced at any place must be regarded, not as having its origin in that particular locality, but as derived from the great tidal wave which has been generated in a far distant latitude. The tidal wave which washes the shores of Britain comes from the south-west. On approaching the British shores, it divides,—one branch setting up the English Channel, while another passes up the sea which divides Great Britain and Ireland, and a third branch passes to the westward of Ireland. The wave which passes to the west of the Irish and Scotch coasts afterwards sets to the east and south-east, flowing down the eastern coasts of Britain, and meeting, off the south-eastern coasts of England, the tidal waters which have reached the same point by the shorter course up the Channel. The precise time of high-water at any given place presents, therefore, a problem which is complicated by many conditions.

32. Again, the western shores of Britain uniformly experience higher tides than the eastern coasts, for their geographical position exposes them to the full force of the tidal wave as it advances from the south-west. In the case of such estuaries as the Solway Firth,
Morecambe Bay, and the mouth of the Severn, the shape of the land—narrowing upwards in the direction in which the tidal wave advances—accounts for the great height of tide which is experienced. The advancing wave becomes, under such conditions, a *bore*, or head wave, which rolls up with extraordinary velocity and force.

33. In the open ocean, where there is no resisting power to impede the steady onward flow of water, the height of the tide is inconsiderable. Upon the coasts of such islets as St. Helena, Tahiti, or the numberless groups of the Pacific, the difference of level between high and low water rarely exceeds five or six feet. It is when the tidal wave meets, in its advancing course, with the resistance presented by lines of coast, that its flow is retarded, and its height becomes increased or diminished, in accordance with the particular geographical conditions of any given locality.

[Inland seas seldom experience any considerable tides, and, in many cases, have no perceptible tide. Owing to the limited extent of such seas as compared with the great oceans, the lunar influence extends over too large a portion of their surface at the same instant of time to allow of the generation of any considerable tidal wave; for the tidal wave is only called into existence by drawing away the waters from one part to another part of the ocean. The Mediterranean is, for the most part, a tideless sea, though at the head of the Adriatic there is a rise and fall of a foot or two. The Red Sea, on the contrary, has considerable tides. The opposite sides of the Isthmus of Suez hence experience widely different conditions in this regard. A like contrast is presented by the opposite shores of the Isthmus of Panama. Upon the Atlantic coasts of that isthmus the tides are scarcely perceptible, while on the Pacific shores the difference of level between high and low water is upwards of 27 feet.]

34. **Co-tidal Lines**.—At the times of either new or full moon, the sun, moon, and earth occupy relatively to one another the same places in the heavens; hence high water at new and full moon, in any given locality, recurs at precisely the same hour. A line drawn on the map to connect places which are subject to like conditions in this regard—that is, a line connecting places which experience high-water at new and full moon at the same hour—is called a *co-tidal line*. A series of co-tidal lines, drawn upon a map, with an indication of the hour proper to each, shows the advance of the tidal wave, and its rate of progress from one part of the coast to another part. Thus it takes thirteen hours for the tidal wave to travel from the coast of Tasmania to the Cape of Good Hope; in the succeeding eleven hours it reaches the Canary Islands, and in four hours more the western shores of Britain.
35. **Currents.**—But, besides the winds, which maintain the surface of the water in constant motion, and the tides, which cause a continual change in their level, there are streams in the ocean, equivalent to rivers on the land, but on a scale of vastly greater magnitude. These ocean-rivers are known as *currents*, and a knowledge of their direction, rate of flow, and other conditions, is of the highest importance to the navigator.

36. **Causes of Currents.**—It is not difficult to account for the existence of currents in the sea. The mobile nature of water causes it to yield to every pressure. Whatever disturbs the equilibrium of the whole fluid mass occasions a transference of its particles from one place to another; and if the disturbing influence be constant, a constant motion of the waters is the necessary result. If two fluids, or two portions of the same fluid, possessing different densities, be placed in contact, a movement of their particles is generated. The denser portions sink towards the bottom, and form the lower strata of the whole, while the lighter portions rise to the surface. The mingling of oil and water in one vessel serves to illustrate this.\(^1\)

37. Now the sea is not of uniform density. Water becomes heavier in proportion as it is colder. The warm water of intra-tropical latitudes is specifically lighter than the cooler water of temperate regions, and that again possesses less density than the colder water of the polar seas. These differences are constant, for the cause by which they are occasioned, the varying amount of solar heat, is in continual operation. Hence the movements which they occasion in the water are constant also. The colder water of polar latitudes has a tendency to distribute itself over the lower strata of the ocean, while the warmer water of equatorial latitudes seeks to diffuse itself over the surface. A flow and re-flow in the waters of

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\(^1\) Dr. Carpenter illustrates the vertical circulation between the polar and equatorial waters, by the following experiment:—

![Diagram](image-url)
the ocean, regarded as a whole, is thus generated: currents of warm water in a direction from the equator towards the poles, and currents of cold water in the opposite direction, being the result. Various causes operate in modifying this normal direction, one of the most obvious of them being the shape of the land, which necessarily gives a partial direction to the streams that wash its coast, while it is also in some degree a consequence of the existence of such agencies. The particular form and depth of the ocean's bed affect similarly the direction of deep-sea currents, and, like the shape of the visible land, are to be regarded at once in the light of causes and consequences.

38. The varying extent to which evaporation takes place in different latitudes is another explaining cause of ocean streams, or currents. Its tendency is to set the waters of high latitudes in motion towards the warmer regions of the globe, in order to supply the waste occasioned by excessive evaporation thereon. Polar currents continually carry the cold water of Arctic and Antarctic seas towards the warm belt of the tropics, there to be converted, under the burning rays of a vertical sun, into the masses of vapour which are afterwards carried by the wind over neighbouring lands, and returned to the earth in copious floods of rain. We see the operation of this cause in the floating ice which currents, flowing from the direction of the Arctic and Antarctic poles, continually bring into the zones of temperate water.

39. Influence of the Earth's rotation.—A condition of nature which importantly affects currents is found in the earth's diurnal rotation—that is, its motion on its axis in a direction from west to east. It is the more important to understand this, because it affects the currents of the atmosphere (or winds) in precisely the same manner that it does the currents of the ocean. The earth's axial rotation is not of itself a cause of either currents or winds, for land, sea, and air, all have the same eastwardly motion. But a transfer of either sea or atmosphere from one part of the globe to another part where the axial motion is either more or less rapid, must of necessity result in a modification of the normal motion which such transferred portion of sea or air previously possessed. A little reflection serves

with the water, and heated at one end by a lamp at A. A little blue colouring liquid is put into the water near the ice, and a little red colour near the hot metal. A continuous circulation in the direction of the arrows is the result. The end A, of course, represents the tropical, and D, the polar, regions. The effects of polar cold and tropical heat is thus clearly demonstrated, and had the earth been entirely covered with uniformly-deep water, subject to no other disturbing influences, a regular vertical and meridional circulation of the water would be manifest. (See also Geography of the Oceans, p. 94).
to explain this. The earth makes one complete rotation on its axis in twenty-four hours. At the equator, the earth is twenty-four thousand miles round, and any given spot in that line is therefore continually moving in an eastwardly direction at the rate of a thousand miles an hour. But with every successive degree of removal from the equator towards either pole, the circles which measure the earth's circuit are progressively smaller. The rate of axial motion under every successive circle becomes therefore progressively less, for the smaller circle only makes a single rotation within the same period of time as the larger circle—that is, twenty-four hours. Thus, under the 60th parallel of latitude, the measure of the earth's circuit is only 12,000 miles, or half the circuit of the equator. Any spot in the latitude of 60° has hence an axial motion equivalent only to five hundred miles an hour—or half the rate of motion proper to a place under the equator. At the poles—the extremities of the earth's axis—the axial motion has no existence.

40. Now, suppose a current—by whatever cause generated—to be set in motion from the neighbourhood of the pole towards the equator. This current, were the earth at rest, would travel along the line of a meridian—that is, it would move from north to south, if in the northern hemisphere, and from south to north, if in the southern half of the globe. But instead of being at rest, the earth is moving on its axis, and the current necessarily shares in this axial motion. Under whatever parallel we may suppose the current to originate, there is a given rate of speed proper to the axial motion of that parallel. But in travelling towards the equator, the current is advancing into regions of continually increasing rate of axial motion, and, unable at once to acquire this more rapid rate of eastwardly rotation, it constantly lags behind the general motion of the regions towards which it is moving, and acquires, hence, some amount of westwardly direction, while still preserving its general advance towards the equator. In other words, its actual motion, instead of being along the meridian, is a resultant of two directing forces. If in the northern hemisphere, it acquires a motion from the north-east (instead of from due north)—that is, it becomes a south-west current. If in the southern hemisphere, its actual motion is from the south-east (instead of from due south,) and it becomes a north-west current.

41. Suppose the contrary case, of a current setting out from the neighbourhood of the equator towards either pole. Disregarding the earth's axial motion, such a current would have, in the northern hemisphere, a direction from south to north; in the southern hemisphere,
a direction from north to south. But in this case, the advance of the stream is from regions of quicker axial motion into regions of diminishing eastwardly motion. The advancing current, preserving for a time its superior rate of eastwardly motion (proper to the latitudes of its origin, and only gradually lost in its onward course), gets continually in advance of the axial motion proper to higher parallels—or, in other words, it acquires a resultant motion which is to the eastward of the meridian. Hence, in the northern hemisphere, a current which, if the earth were at rest, would travel from south to north, acquires a motion *to the east of north*—that is, it becomes a north-eastwardly current. In the southern hemisphere, a like stream, acquiring a similar motion *to the eastward of south*, becomes a south-eastwardly instead of a due southwardly current.\footnote{1 It follows from these conditions that the warm surface-currents (or Tropical Streams, as they might with propriety be called), within the northern half of the globe, are directed towards the western shores of the Old and New Worlds—*i.e.*, to the coasts of Western Europe and the west side of the North American continent: while the cold waters of the Arctic current are directed towards the eastern coasts of the same regions—*i.e.*, towards the east sides of Asia and North America. It is to this cause that the superior warmth of western over eastern coasts may be mainly (perhaps altogether) attributed.}

[Recapitulation.—The causes which account chiefly for the existence of ocean-currents are:—

1. Difference of temperature, and consequently of density, in the waters of the ocean.

2. The earth’s rotation on its axis, which modifies the normal direction of the streams generated by the preceding cause.

3. The influence of perennial or seasonal winds, occasioning a drift of the surface-waters in the direction of the air-current (or wind).]

42. Classification of Currents.—Most, if not all, of the deep-sea currents may be resolved into outlying portions of two great streams, generated under the influences above adverted to, *viz.*, a *warm current*, flowing from the direction of the equator towards the poles, and a *cold current*, setting from the polar latitudes in the direction of the equator. The resultants of these initial and normal movements, however, exhibit the modifying influences of shape of land, depth of ocean-bed, and other conditions: the actual direction of currents, as local phenomena, deviates in many cases from that of the great ocean-streams (warm or cold) to which they respectively belong.

[Geographers distinguish between *constant* or *stream currents* and *periodical* or *variable currents*—the former flowing regularly in the same direction at all times, while the latter change their direction according to the season. The distinction between *deep-sea currents* and *drift currents* is obviously implied in the terms used—the former being constant currents of considerable depth, while the
latter are due principally to the constant agency of the wind, blowing for a
length of time (or, as in certain parts of the globe, continually) in the same
direction. Surface currents also generally overlie under-currents flowing in a
contrary direction. Of two related currents the principal stream is called the
current, in contradistinction to the return stream or counter-current. It should
also be noticed that the direction of the ocean currents is expressed differently to
that of air currents. Thus, a "north wind" is a wind blowing from the north,
but a "northerly current" is a current flowing towards the north, &c.]

43. Principal Currents.—The accompanying chart shows clearly the position
and direction of the chief currents, and should therefore be carefully examined.
As we shall again describe the currents of each of the great oceans separately, it
will suffice here merely to take a general view of the principal currents.
Commencing in the south, we have a general drift of the cold waters of the
Antarctic Ocean into the Pacific, between New Zealand and Cape Horn. Off the
latter the drift divides; one branch flowing east into the Atlantic, while the
other proceeds along the western coast of South America as the Peruvian
Current, and finally merges into the southern portion of the Equatorial Current
of the Pacific, which sweeps across to the Malay Archipelago. The northern
branch of the equatorial stream curves north-east as the Japan Current, which
holds on its way to the American coast, where it is deflected south—a portion of
it joining the variable Mexican Current, but the main stream curves to the west
as a counter-current. The various streams which flow from the Pacific through
the numerous seas and channels of the Malay Archipelago, form a similar
Equatorial Current in the Indian Ocean. North of the equator the current is
variable—south of it the main stream sweeps across towards the African coast.
Bifurcating, one branch curves south through Mozambique Channel, the other
flows along the east coast of Madagascar, uniting off the coast of Natal to form
the Cape Agulhas Current; one portion of which flows round the Cape of Good
Hope into the Atlantic, while the remainder is deflected east as the Southern
Counter-current. The Atlantic Equatorial Current sweeps to the west, dividing
off Cape St. Roque into two branches, one of which turns south-west along the
Brazilian coast, while the other trends north-west through the Caribbean Sea
and the Mexican Gulf, whence it issues as the celebrated Gulf Stream, which
becomes diffused in mid-ocean. The cycle of circulation in the North Atlantic
is completed by the African Current, which trends along the western coast of
the continent, finally merging in the Equatorial Current. Two polar currents
also flow into the Atlantic; one from Baffin Bay, through Davis Strait, and
another along the eastern coast of Greenland,—combining off Cape Farewell in
the cold current which flows round Newfoundland, and along the American
coast as far south as Cape Hatteras, where it sinks below the adjoining thermal
current—the Gulf Stream—finally entering the Mexican Gulf as an under-current.

[Regarding the ocean as a whole, it is obvious that all its movements are, in
greater or less degree, connected with one another. The currents of one ocean,
in most cases, if not in every instance, are continuous with those of the other
oceans. The general direction of the waters, within tropical latitudes, is to the
westward: within temperate latitudes the direction is the reverse, or to the
eastward In the higher latitudes, the direction, in either hemisphere, is from
the pole towards the equator; and the remarkable feature is the similarity that exists between the chief currents of the great oceans. The equatorial drift is common to the Pacific, Indian, and Atlantic Oceans—in each it is twofold—its northern and southern portions being separated by a counter-current. The Japan Current of the Pacific is, in many respects, the counterpart of the Gulf Stream of the Atlantic. All the great currents have also compensating return currents. Thus in the Atlantic the great flow to the Mexican Gulf is returned by the Gulf Stream and African Current. The South Equatorial Current in each of the three great oceans is compensated by a similar connecting or counter-current.]

44. Having thus described the ocean as a whole, we proceed to notice briefly the principal features of the main divisions of the great "world of waters" in the following order: (1) Atlantic Ocean, (2) Pacific Ocean, (3) Indian Ocean, (4) Antarctic Ocean, (5) Arctic Ocean.

I.—The Atlantic Ocean.

45. Boundaries and Extent.—The Atlantic Ocean extends upwards of 9,000 miles in the direction of north and south—taking the lines of the north and south polar circles as marking its limits. Its proportions in the opposite direction, east and west, are greatly inferior. Its widest limits are under the tropic of Cancer, where the shores of the African and American continents are upwards of 5,000 miles apart. Both to the northward and southward of that line they gradually make nearer approach. Under the 40th parallel of north latitude, the breadth of the Atlantic (between Portugal and the shores of the United States) is diminished to less than 3,400 miles; between the coasts of Ireland and Labrador, to less than 2,000 miles; in the 60th parallel of latitude (between Norway and the southern extremity of Greenland,) to fewer than 1,700 miles. Under the direct line of the equator, the opposite shores of Africa and South America are 4,200 miles apart; but the shortest measure between the coasts of Senegambia and Brazil—respectively within a few degrees of the line on either side—falls considerably below the half of those dimensions, being less than 1,800 miles. Thence to the southward the shores of the African and South American continents gradually recede, and in the parallel of the Cape of Good Hope they are nearly 4,000 miles apart.

46. Configuration.—The Atlantic Ocean has the form of an immense elongated valley, which winds from north to south somewhat in the shape of the letter S, like the successive curves in the stream of a river. Between the Arctic Circle and the tropic of Cancer, the direction of its coasts upon either side is from north-east to south-west. Thence to the equator, the direction becomes reversed—or from north-west to south-east. From the easternmost headland of Brazil southward, the shores of the South American continent resume the same direction as that of the coasts upon either side of the North Atlantic within temperate latitudes—that is, from north-east to south-west.

47. Inland Seas.—The Atlantic is distinguished above either of the other great oceans by its numerous inland seas, gulfs, bays, and other inlets, and the
consequent development of coast-line which its shores exhibit. This feature characterises the Atlantic upon either side of its extensive basin, but is more especially noteworthy in the case of its eastern than its western shores. A like characteristic distinguishes the shores of the Arctic Ocean, which, as we have seen above, belongs strictly to the Atlantic basin.

48. The strictly inland seas which belong to the Atlantic Ocean are—the Mediterranean and Black Seas, the Baltic Sea, and Hudson Bay, only the last-named of which is on its western side. But a great number of arms of the sea which penetrate within the land—some of them divided from the open expanse of the ocean by islands or outlying portions of the continent—may be enumerated as belonging to either side of the Atlantic shores. Among those on the eastern side, besides the various gulfs that belong to the Baltic and Mediterranean Seas, are the North Sea, the Zuyder Zee, the British Channel, the Bay of Biscay, and the Gulf of Guinea. Upon the western side of the same ocean are Baffin Bay, Hudson Bay, the Gulf of St. Lawrence, the Bay of Fundy, the Gulf of Mexico, and the Caribbean Sea. With most of these, again, there are connected other channels and partially land-enclosed seas, as in the instance of the channels leading to the entrance of the Baltic, the "narrow seas" that belong to the British archipelago, and those that divide the numerous islands of the Western Indies.

49. Coast-Line.—The result of this configuration of the Atlantic is a vast development of coast-line—surpassing in extent that of either of the other great oceans, and probably superior to them unitedly. The Mediterranean Sea alone, with its gulfs, exhibits a coast-circuit of more than 13,000 miles, and the Baltic (even disregarding the multitude of minor inlets which belong to its shores) has a like circuit of little less than 4,000 miles. The British Islands alone comprehend a coast-line of more than 6,000 miles, if the almost numberless indentations of the Scotch and Irish shores be taken into account. These facts acquire additional importance amongst the truths of physical geography when regarded in connexion with the circumstances already adverted to—namely, that the longer slopes of the land are everywhere turned towards the Atlantic and Arctic Oceans, and that so great a number of the larger rivers of the globe are discharged into their waters.²

50. Depth and Form of its Basin.—Formerly the basin of the Atlantic was regarded as a vast canal-like abyss, deepest along a line midway between the Old and the New Worlds. Recent researches, however, show that instead of a medial line of maximum depth, a most remarkable ridge or sub-marine plateau extends from Cape Farewell on the north to Tristan d'Acunha on the south.³ The course

₁ That is, land-enclosed seas—only connected with the ocean by a narrow channel of entrance.
² The Atlantic is scarcely half the size of the Pacific, yet its drainage area is 2½ times greater, being 19,050,000 square miles, while that of the Pacific is only 8,460,000 square miles.
³ The northern and southern portion of the great central ridge are distinguished as the Dolphin Ridge and the Challenger Ridge. The broad plateau between Ireland and Newfoundland, along which the sub-marine telegraph lines are laid, is known as the Telegraphic Plateau.
of this great central ridge, which rises on an average to within 1,900 fathoms below the surface, may be roughly marked by a line drawn from Cape Farewell to the Azores—thence sweeping round to St. Paul's Rocks—following the equator as far as 12° W. long., where it suddenly turns south by Ascension to Tristan d'Acunha. The first portion of this central ridge is comparatively broad; south of the Azores it gets narrower, but widens out again south of Ascension, and between the Cape of Good Hope and the mouth of the La Plata is nearly 30° wide. Two lateral ridges are given off—one connecting with South American coast at Cape Orange, another of less elevation trends to the South African coast at Cape Voltas. These ridges divide the Atlantic into four basins—the eastern basin, between the central ridge and the coasts of Europe and Africa, and extending from Ireland to the Cape, with an average depth of 2,500 fathoms: the north-western basin, between the central ridge and the North American coast, and extending from the Grand Banks of Newfoundland to Trinidad, with an average depth of 3,000 fathoms; the south-western basin, between the South American coast and the central ridge, with an average depth of over 2,500 fathoms; and lastly, the southern basin, which extends south of the Cape and the Falkland Islands. The greatest depth ascertained was 3,875 fathoms, or 4½ miles, at a point about 80 miles north of St. Thomas, one of the West Indian Islands. The average depth of this ocean is probably about three miles. It is noteworthy that the belt of water along the Norwegian and British coasts is so shallow, that were the level to fall 100 fathoms, the British Isles would be connected by dry land with France, Holland, and Denmark, and separated from Norway only by a narrow channel.

51. Currents.—Nearly all the chief currents of the Atlantic branch from the great Equatorial Current, which crosses the ocean from east to west, in the immediate neighbourhood of the equator—that is, it flows from the coasts of Africa towards those of South America. On approaching the latter, a branch known as the Brazilian Current leaves the main stream, and flows in a south-westwardly direction along the shores of Brazil. Off the mouth of the La Plata, this current seems to be deflected due east as the Southern Connecting Current, which probably joins the northerly drift off the Cape of Good Hope. The main stream flows along the north-eastern coasts of South America, and enters the Caribbean Sea through the numerous channels between the Lesser Antilles. Thence pressing onward through the channel of Yucatan, it makes the circuit of the Gulf of Mexico, where, under a tropical sun, it acquires its characteristic temperature and velocity, and finally sweeps through the Strait of Florida as the Gulf Stream, the most wonderful and important of all the great currents of the ocean. The general course of the Gulf Stream is north-eastward parallel to the shores of the United States, past Cape Hatteras (lat. 35° 13'), and thence in the direction of the “Banks” of Nantucket and Newfoundland,—between the meridians of 48° and 60° W. of Greenwich—along the southern edge of which it is traceable, though with greatly reduced conditions of velocity and temperature. Within this portion of its course, the waters partly interlace with those of the cold Greenland or Baffin Bay Current, and before reaching the meridian of the “Great Bank” the warm water of the Gulf Stream has thinned off to a mere surface drift. Within the initial portion of its course, the Gulf
Stream is distinguished by its superior warmth, compared with the temperature of the adjacent ocean. The difference amounts to 20°, and sometimes even to as much as 30°. The Gulf Stream may here be likened to a river of warm water, flowing between banks of colder water. The velocity of the current is greatest in the commencing or narrower portion of its course, and gradually diminishes as it spreads out to wider dimensions. As far out from the Gulf of Mexico as the coast of Carolina, the water of the current is of an indigo hue, and is readily distinguishable in appearance from the common sea-water, which is of a pale green. The tendency of the Gulf Stream, regarded as an agent of influence upon climate, is of like description to the greatly more extended influences exerted by the tropical waters at large; since, as in the case of the latter, its final direction is towards the coasts of Western and North-western Europe. But the effects due to it have been very greatly exaggerated, and any influence of the kind which it may exert is probably of the most trivial description. The general 'set' of the tropical waters in the direction indicated sufficiently accounts for the relatively high temperature of the European coasts and the waters of the adjacent seas. From the different warm-water area which marks the termination of the true Gulf Stream, there is a perceptible southerly drift, which divides off Cape Verde—the main portion curving towards and finally joining the North Equatorial Current, the rest bending round the coast as the Guinea Current, also merging into the South Equatorial Current. The Arctic Current is formed by the junction off Cape Farewell of the Davis Strait Current and the East Greenland Current. It flows along the coasts of Labrador and Newfoundland, with a southwardly course, and brings down the cold water and the vast floating icebergs of Baffin Bay into the western parts of the Atlantic, producing effects upon climate precisely the reverse of those that ensue from the Gulf Stream. The influence of the Arctic Current is perceptible as far south as Cape Hatteras; along the north-easterly portion of the United States' seaboard the cold-water current from Baffin Bay, and the warm current of the Gulf Stream, flow side by side, parallel to one another, but preserving opposite directions, and without mingling their waters. This cold current finally sinks under the Gulf Stream, and enters the Mexican Gulf as an under-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.'

II.—The Pacific Ocean.

52. Extent and Shape.—The Pacific is by much the largest of the oceans, and covers more than a third part of the earth's surface—being, in fact, considerably greater in dimensions than the united area of all the continents and

1 It should be noticed that wherever a circular motion is manifested in any area of water, all the floating substances in that area will accumulate near the centre, where the motion is less felt. The three great currents of the Atlantic—the Equatorial Current, Gulf Stream, and African Current—form a continuous stream, circling round an area of comparatively still, and towards the centre almost stagnant, water. The effect of these currents is seen in the vast Sargasso Sea, which occupies the centre of the area they enclose.
islands of the globe. In the direction of north and south—measuring from Behring Strait to the Antarctic Circle—the waters of the Pacific Ocean stretch, unbroken by land, through more than 130 degrees of latitude, or upwards of 9,000 miles: from east to west—between the 90th meridian west, and the 104th east, of Greenwich—its proportions are still greater, exceeding 170 equatorial degrees, or above 12,000 miles. An ocean that measures twelve thousand linear miles in one direction, and nine thousand in another, must of necessity exercise a vast influence over all lesser features of the earth's surface, and is of the highest importance to mankind. It is under the line of the equator that the Pacific attains its widest limits. Thence, both in the direction of north and south, its opposite shores gradually approximate. Under the line of the northern tropic they are separated by 136° of longitude, and by rather more than that distance along the line of the southern tropic. To the northward of the tropic of Cancer, the coasts of North America and Asia make rapid approach towards one another, and at Behring Strait they are divided by less than 60 miles. The Pacific exhibits, in fact, the shape of an immense oval, the longest diameter of which coincides with the line of the equator. But the circumference of this oval is imperfect to the southward, where the waters of the vast ocean stretch—uninterrupted by land—to the line of the Antarctic circle, perhaps to the pole itself.¹

53. Inland Seas, &c.—The circuit of the Pacific exhibits no true inland seas, such as those that belong to the Atlantic basin. Nor do its eastern shores display, except in the instance of the Gulf of California, any indentations of a magnitude comparable to those that belong to the correspondent portion of the Atlantic sea-board. But the western shores of the Pacific exhibit a feature peculiarly characteristic of this ocean, in the range of seas and gulfs which are found between the mainland and the neighbouring groups of islands. Among them, proceeding from north to south, are the Sea of Kamtchatka, the Sea of Okhotsk, the Japan Sea, the Yellow Sea, the East Sea (of China), and the China Sea, with their numerous smaller gulfs and channels. These are not inland seas, like the Mediterranean or the Baltic. They are merely extensions of the ocean itself, partially divided from its main body by a succession of island-groups. Between these islands there are numerous channels, which connect the partially land-locked gulfs of the Pacific with the ocean itself, and also with one another.

54. Islands.—The Pacific Ocean is likewise distinguished by the numerous islands—for the most part of exceedingly minute proportions—scattered over its vast expanse. Some of these islands are of volcanic origin, but by far the greater number are of coral formation. It is worthy of notice that all the larger islands lie along the western side of this ocean—extending in an almost unbroken line from Alaska to Australia, and enclosing the remarkable series of inland seas already referred to. The eastern division of this ocean, between the Sandwich and Marquesas Islands and the opposite coast of the American conti-

¹ Taking the purely physical divisions of the ocean, and ignoring the theoretical limits, the three great oceans are but the northerly extensions of the vast circumterrestrial Southern Ocean—the Atlantic forming an elongated gulf, and the Pacific an immense bay, between the Old and New Worlds.
nent, is singularly free from islands—with the exception of the Galapagos group, the few other islands are in close proximity to the coast, from which they are divided only by narrow channels and straits.

55. Depth and form of its basin.—Owing to the immense number of islands and islets scattered over its surface, it was formerly supposed that the Pacific was on the whole shallower than the Atlantic. But the researches of the Challenger, Gazelle, Tuscarora, and other expeditions, prove that this supposition is incorrect, and that the general depth of the Pacific is fully equal to, if it does not exceed, that of the Atlantic. The greatest known depth in the Atlantic is 3,875, but in the Pacific the Tuscarora obtained several soundings of 4,000 fathoms; the greatest depth, however, was found by the Challenger in 11° 24' N. lat., and 143° 16' long., between the Caroline Islands and the Ladrones, where a sounding of 4,575 fathoms, or about five and a quarter miles, was obtained. The basin of the Pacific may be broadly divided into four sections, (1) the North-Eastern basin, along the American coast, from Alaska to Chili, distinguished from the other basins by the almost entire absence of islands at any considerable distance from the coast. In this basin 3,000 fathoms is a very general depth; and in its northern portion, off Japan, depths of over 4,000 fathoms have been observed. (2) The Southern basin extends from the Antarctic basin on the south, to the sub-marine ridge which stretches from New Zealand to the Chilian coast. The general depth of this basin is about 2,000 fathoms. The Central basin, south of Japan, although studded with islands, has a much greater average depth than any other portion of the Pacific—many of the islands rising from a depth of over 3,000 fathoms. But the best defined of all the Pacific basins is the Western basin, lying between the chain of islands already mentioned and the coast of Asia, and consisting for the most part of shallow and nearly land-locked seas, such as the Sea of Okhotsk, &c. The portion of this basin east of the Caroline Islands, however, has an average depth of 3,000 fathoms, and is otherwise remarkable as the cul de sac whence issues the great thermal current of the Pacific.

56. Currents.—Commencing in the south, we have the Antarctic Current, which consists in a general drift of the waters of the Southern Ocean to the northward. Off the south-western coast of South America this drift divides into two streams—one bearing eastwards round Cape Horn into the Atlantic, while the other, known as the Peruvian Current, flows along the coasts of Chili and Peru. This current is characterised by a comparatively low temperature, which it maintains nearly as far as the equator, where it curves west, and merges in the southern branch of the great Equatorial Current of the Pacific. The latter curves south along the east coast of Australia, forming the variable East Australian Current. The North Equatorial Current pours its waters into the deep basin between the Ladrones and Philippines, and the Bellew Islands and Japan, whence it issues as the powerful and rapid Japan Current. ¹ This

¹ The Japanese are said to be well aware of the existence of this current, and to have given it the name of "Kuro-Siwo," or Black Stream, an appellation in all probability derived from the deep-blue colour of its water, when compared with that of the adjacent ocean. In this characteristic, the result of its greater salinity, as well as in other regards, this current resembles the Gulf Stream of the North Atlantic. Like that stream, too, the
current—the "Gulf Stream" of the Pacific—sets north-east past the shores of Japan, and in latitude 45° N. bifurcates; a minor drift pressing between the Aleutian Islands into Behring's Sea, and thence through Behring's Strait into the Arctic Ocean. But the main stream sweeps across to the American coast, finally curving west, and merging into the North Equatorial Current. Another remarkable current, known as the Mexican Current, flows along the coasts of Mexico and Central America, its direction varying with the change from winter to summer, or the reverse. During the former season its course is to the south-eastward; during the opposite half of the year this direction is reversed, and the current sets to the north-west.

III.—The Indian Ocean.

57. Boundaries and Extent.—The Indian Ocean is much smaller than the Pacific or Atlantic, and has a marked feature of distinction from either of those oceans in the fact of its being limited by land to the northward. The waters of the two other great oceans stretch to the confines of the frigid zone, in either direction, north and south alike. The Indian Ocean is bounded on the north by the continent of Asia, and is only open in the direction of the Antarctic circle. Important consequences in regard to the climate and other conditions in the physical geography of the lands that lie around its shores, ensue from this fact. Under the equator, the Indian Ocean measures little less than four thousand miles across. Further south, along the tropic of Capricorn, the breadth is increased to upwards of five thousand miles. Its area has been variously estimated at from 17,000,000 to 25,000,000 square miles.

58. Inland Seas, &c.—The Indian Ocean has two inland seas,—the Red Sea and the Persian Gulf. These are of much smaller dimensions than the inland seas which belong to the Atlantic basin. The Red Sea has an area of 180,000 square miles, and is connected with the ocean by a single channel of entrance—the Strait of Bab-el-Mandeb, sixteen miles across. The Persian Gulf, about 95,000 miles in area, is entered by the Strait of Ormuz, which has a breadth of 40 miles. The Gulf of Aden, the Gulfs of Cutch and Cambay, the Bay of Bengal, and the Gulf of Martaban, are offsets of the Indian Ocean, but are neither inland seas nor land-enclosed gulfs. The waters of the Indian Ocean are connected with those of the Pacific by the channels which divide the innumerable islands of the Malay Archipelago. The Strait of Malacca and the Strait of Sunda are the two most important of these passages. They lead directly from the Indian Ocean into the China Sea, and are annually navigated by a vast number of vessels of every class, engaged in the extensive traffic which belongs to the shores of that richly-diversified portion of the globe. Singapore, at the southern extremity of the Malay peninsula, and
Batavia, on the northern coast of Java, are the emporiums of European commerce in this region, and have been called into existence by the energies of the British and Dutch traders thither. Under a more eastwardly meridian, the broader passage of Torres Strait—so called from its discoverer, a Spanish navigator of the seventeenth century¹—forms an important channel of connexion between the Indian and Pacific Oceans. But the coral reefs with which it is beset render it perilous to the navigator. The "Great Barrier Reef" of coral, which lies beyond, stretches for about a thousand miles along the eastern sea-board of the Australian continent, and the mariner threads his way with difficulty through its narrow and intricate passages.

59. Depth and Form of Basin.—The greatest depth as yet recorded in the Indian Ocean was observed by the Gazelle, in the deep basin between Java and the north-western coast of Australia, where two soundings of 3,010 and 3,020 fathoms respectively were obtained. The greatest depth observed by the Challenger was only 2,254 fathoms. The general depth south of the 35th parallel S. lat. varies from 1,500 to 2,000 fathoms; the main basin has an average depth of 2,500 fathoms, deepening towards the east to 3,000 fathoms. South of Australia the general depth is not far short of 2,000 fathoms. The Red Sea, Persian Gulf, and Mozambique Channel are each under 1,000 fathoms in depth. The main basin of the Indian Ocean lies north and east of the Kerguelen Plateau—the Bay of Bengal forming its most northerly, and the Arafura Sea its most easterly, extension. What may be termed the north-western basin is divided from the main basin by a submarine ridge extending from the south-west coast of India to the African coast. The south-western basin of the Indian Ocean is entirely included in the so-called "Southern Ocean," and extends from the Antarctic Plateau² on the south to the Kerguelen Plateau on the north.

60. Currents.—The current system of the Indian Ocean, north of the equator, is complicated and uncertain—the drifts in the Bay of Bengal and the Arabian Sea varying their direction with the monsoons, which blow for one half of the year from the north-east, and from the south-west during the other half. South of the equator, the currents are similar to those of the Southern, Atlantic, and Pacific Oceans. First we have the Antarctic Drift Current, flowing in a north-easterly direction from the south polar basin, and dividing off Cape Leeuwin—one branch holding on east along the south coast of Australia—the other proceeding north along the western coast of Australia as far as North-East Cape, off which it curves west with the South Equatorial Current of the Indian Ocean. The latter divides off the Mauritius—one section flowing along the east coast of Madagascar—the rest curving round that island and flowing through the Mozambique Channel. Uniting off the Natal coast, the stream curves round the South African coast as the well-known Agulhas Current, which is deflected east as the Great Southern Connecting Current. The latter sets towards

¹ Luis vas Torres, who held the second place in rank in the expedition of De Quiros, in 1606.
² The culminating points of this plateau are Marion, Prince Edward, Crozet, Kerguelen, Amsterdam, and St. Paul's Islands. A line connecting these islands will show approximately the position of the ridge.
Australia with an initial velocity of 50 miles a day. Of the minor currents the most important is the Equatorial Counter-Current, flowing east, a few degrees south of the equator. There is also a constant inflow through the Straits of Bab-el-Mandeb, in the Red Sea, compensating the excessive evaporation to which it is subject.

IV.—The Arctic Ocean.

61. Boundaries and Extent.—The Arctic Ocean—looked at either on the artificial globe, or on a map projected upon the plane of the Equator—exhibits a circular and nearly land-enclosed basin, bounded by the northern coasts of Europe, Asia, and America. It is open to the Atlantic through the broad sea that flows between the shores of Norway and Greenland, upwards of a thousand miles across. It is connected with the Pacific only by Behring Strait, which is less than sixty miles across in its narrowest part. The total area of the Arctic basin is estimated at 5,550,000 square miles.

62. Inland Seas, &c.—The principal seas and inlets which belong to the Arctic basin are: (1) On the coast of Europe, the White Sea. (2) On the coast of Asia, Sea of Kara, Gulfs of Obi and Yenesei. (3) Of the numerous gulfs, bays, straits, and channels which divide the multitude of islands that adjoin the northern and north-eastern coasts of North America, the principal are:—Baffin Bay, connected with the Atlantic by Davis Strait, and with the "Palæocrystic Sea," north of Greenland, by Smith Sound, Kennedy Channel, and Robeson Channel; Gulf of Boothia; Coronation Gulf, Mackenzie Bay, Lancaster Sound, Barrow Strait, Melville Sound, and Banks Strait, leading from Baffin Bay into the Arctic Sea on the west.

63. The Arctic Ocean and its various ice-encumbered channels supply the long-sought "North-West passage" between the Atlantic and Pacific, by way of the northern shores of the New World. This passage, after a lapse of three centuries since it was first sought, is now proved to exist. It is, however, useless for purposes of commerce, owing to the vast quantity of ice by which the seas of this region are encumbered, and the consequent peril (if not, as is the case in many seasons, the utter impossibility) of their navigation. Davis Strait, Baffin Bay, Lancaster Sound, Barrow Strait, Melville Sound, the Arctic Ocean, and Behring Strait, form a continuous channel of connection between the Atlantic and Pacific. This channel, which may be readily traced out upon the map, forms "the North-West passage."

64. The limits of the Arctic Ocean in the direction of the pole are unknown. The farther distance northward to which its shores have been traced is through Smith Sound, at the northern extremity of Baffin Bay. Dr. Kane (of the United States Navy) passed two successive winters in the latitude of 75° 37' (in the years 1853-55), and followed the land farther northward to the parallel of 80° 53'. At the farthest point reached there appeared to be an open sea to the northward. In 1875, Sir George Nares succeeded in carrying the "Alert" to the northern extremity of Robeson Channel, where he wintered. In the
following spring sledge parties were sent out, and Commander Markham, with his brave companions, reached a spot in latitude 83° 20' 28" north—the most northerly point on the globe that had been attained.  

65. Depth.—The Arctic Ocean is scarcely anywhere much deeper on an average than 1000 fathoms. The long slopes of Northern Asia and North America indicate a continuous belt of shallow water to a high latitude. The deepest part at present known is between Greenland and Norway, where the Voringen obtained a sounding of 1,800 fathoms. The depth near the ice barrier which checked the progress of the British Expedition was only 72 fathoms.

66. Currents.—The best known currents of the Arctic Ocean are those that flow south along the eastern and western coasts of Greenland, and, uniting off Cape Farewell, proceed south along the coast of Labrador as the Arctic Current. Off the Grand Banks of Newfoundland, this cold, sluggish drift meets the warm current of the Gulf Stream, under which it finally sinks, and enters the Gulf of Mexico as an under-current. The warm north-easterly drift which bathes the British and Norwegian coasts seems to be continued north between Greenland and Spitzbergen, and east between Nova Zembla and Franz Josef Land. A branch of the latter is probably continued eastward along the Siberian coast towards Behrings Strait, where it is deflected to the north-east by the warm current which sets into the Arctic from the Pacific through that strait. The drift then flows north-east towards the Arctic archipelago, and may probably be continued due east through Melville Sound and Barrow Strait into Baffin Bay, finally merging in the Davis Strait Current.

V.—THE ANTARCTIC OCEAN.

67. The Antarctic Ocean has been much less frequently visited than the seas that lie within the northern polar circle, and the space which it covers on the maps is for the most part a blank. Several portions of land have been seen by navigators, at distant intervals, along or near the line of the Antarctic Circle, and have been supposed to form part of an imaginary Antarctic continent. The principal known tracts are—Graham Land, Trinity Land, south of Cape Horn, Enderby and Kemp Land, south of the Crozet Islands, and the irregular coasts of Sabrina Land, Clarie Land, and Adelie Land, south of Australia. But the most extensive region actually visited within the Antarctic Circle, however, is South Victoria, which name was given to a line of coast discovered by Sir James Ross in 1841. Its shores stretch between the parallels of 70° and 78° south, in a direction lying nearly due southward of New Zealand. Two volcanoes (the loftier of them, Mount Erebus, estimated at upwards of 12,000 feet) were visible on this dreary and snow-covered region. Sir James Ross succeeded in penetrating amongst the ice-encumbered seas which adjoin this distant land, as far as the latitude of 78° 4', which is the nearest approach yet made to the South Pole. In

1 For further particulars of the progress of Arctic discovery, see the "Geography of the Oceans, Physical, Historical, and Descriptive" (London: George Philip & Son).
this wide inlet the depth nowhere exceeded 500 fathoms, and it is probable that the average depth of the seas within the Antarctic Circle is under 1,500 fathoms. The maximum depth found within the circle (south of Termination Island) by the Challenger expedition, was 1,975 fathoms, or 11,850 feet. The vast north-easterly drift, known as the Antarctic Current, carries enormous numbers of icebergs and floes as far north as 55° or 50°, that is, 10° nearer the equator than those of the Arctic Ocean. Warm under-currents from the Atlantic and Pacific compensate this surface-drift, and there is also a vast northerly influx of cold water from the Antarctic basin along the bottom of the ocean towards the equator. In the Pacific the cold water at the bottom must be entirely an influx from the Antarctic; but in the Atlantic, the cold influx along the bottom from the Antarctic does not, probably, extend beyond the equator—the open communication between the Atlantic and Arctic basins admitting an under-flow from the North Polar Sea into the North Atlantic.

EXAMINATION QUESTIONS.

1. What proportion of the Earth's surface is covered by the Ocean, and into what basins is it divided?
2. What is known respecting the depth of the sea?
3. What has been ascertained respecting the temperature of the sea?
4. What proportion of saline matter is contained in the sea?
5. To what are the variations in the colour of the sea, observed in particular localities, to be ascribed?
6. What has been ascertained respecting the height of waves? State briefly the nature of wave-motion.
7. To what cause are the Tides due? State, and illustrate by a diagram, the general theory of the tidal movements.
8. What influences modify the normal movement of the tidal wave?
9. What are Co-tidal Lines?
10. What are currents? Recapitulate the principal causes which account for their existence.
11. Enumerate the principal currents of the Ocean, stating the direction of each. State, in summary form, the general direction of the ocean-currents within tropical, temperate, and higher latitudes respectively.
12. What is the shape of the Atlantic Ocean? State also its dimensions.
13. What inland seas belong to the Atlantic basin?
14. State what you know of the depth and currents of the Atlantic.
15. Give some particulars concerning the Pacific Ocean—its shape, dimensions, currents, and other features.
16. In what respect does the Indian Ocean differ materially from either of the other great oceans? What inland seas belong to its basin? Name its chief currents.
17. Describe briefly the Arctic Ocean, noting its inland seas, depth, and currents.
18. Give a few particulars of the Antarctic Ocean.
VIII
RIVERS.

1. The following terms, used in treating of rivers, require explanation.

2. River-basin.—The whole extent of country which is drained by any river, with its tributary streams, is called the basin of that river. The compound term river-basin is hence often used to express such areas of drainage. In like manner it is usual to speak of the basin of the Mediterranean, or any other sea, as a term expressive of the whole area within which all the running waters are ultimately discharged into the sea referred to.

3. Watershed.—The term watershed (or water-parting) is used to express the rise of ground which divides the streams belonging to different areas of drainage. Every two adjacent river-basins are divided by a rise of ground, upon the opposite slopes of which the waters flow in different directions, determined in accordance with the exact nature of either declivity. This rise of ground is the watershed.

4. Watersheds are of the most various character as to elevation, amount of slope, and other conditions. They are formed in some cases by ranges of hills, or high mountain-chains; and in other instances by a rise of land so gentle as to be imperceptible except to the most careful scrutiny upon the ground itself, and to be traced with difficulty upon a map.¹ It was long an error with geographers to regard watersheds as identical with mountain-chains—a fallacy which is even yet hardly exploded. A chain of hills may possess considerable elevation, and yet not constitute a watershed, for streams that have their origin in ground of inferior elevation may traverse the range, by means of openings which the agency of water has originally formed, and which their channels continually tend to deepen. The chalk hills in the south of England are an example of this. The ranges known as the

¹ It is hence an error to regard watersheds (as has sometimes been done) as the foundation of a geographical system, though they are undoubtedly of high importance, and may be studied with advantage.
North and South Downs do not constitute watersheds. The line which divides the streams that run into the Thames from those flowing into the English Channel is found midway between either range, in ground of inferior average elevation, and belonging to a distinct geological formation. Even in the case of high mountain-chains—the Himalaya, for example—the line of watershed is not necessarily coincident with that of the highest peaks. The water-parting between the rivers of Northern India and the streams that flow towards the interior plains of the Asiatic continent, is to the northward of the line of snowy peaks which form the highest portions of the Himalaya. The rivers find their way to the plains below through deep ravines which intersect the mountain-system, transversely to its general direction.

5. Delta.—The term delta is applied to the portions of land enclosed between the various arms into which many rivers divide immediately above their outlets to the sea. It was the triangular piece of land at the mouth of the Nile that the Greeks—from its resemblance in shape to the fourth letter of their alphabet, Δ—first gave the term, since generalised. The Rhine, Danube, Indus, Ganges, Mississippi, and Orinoco, are among examples of rivers which form deltas.

6. Rivers rank first in importance among the natural features of the globe, and are intimately connected with the history and condition of mankind. The course of nations may in many instances be traced along their advancing streams; and the great cities built upon their banks have constituted, in all ages, the seats of empire. The names of the Euphrates, the Tigris, the Nile, and the Tiber, are indissolubly associated in the mind with the greatness of Babylon and Nineveh, of Thebes and Memphis, and of the capital of the Roman world. It is the same in modern times. London, Paris, Vienna, St. Petersburg, Calcutta, New York, Quebec, have the most intimate association of thought with the streams of the Thames, the Seine, the Danube, the Neva, the Ganges, the Hudson, and the St. Lawrence.

7. Every circumstance concerning rivers is an object of inquiry. Their rise, length of channel, outlet, volume of water, rapidity of current, depth and consequent capability of navigation, are among the more obviously important considerations. Many of these are directly connected with the elevation of the ground in which their streams originate, and the geological character of the soil through which they flow. The streams that water highland regions are torrents rather than rivers, while those that flow through the lower
plains naturally possess a gentle current, and expand to a greater volume. The same stream exhibits, in many cases, an instance of either class of rivers, according as the upper or the lower portion of its course forms the object of regard. Between the Ganges of the mountain-region, ere it leaves the gorges and deep valleys of the Himalaya, and the Ganges of the Bengal plain, there is a wide difference in current and volume of water, as well as in other regards.

8. Average Fall and Velocity.—The average fall of a river's bed is indicated by the difference between the altitudes of its source and its outlet, compared with its length of channel, or development. But the amount of fall may differ widely in various parts of the river's course. The velocity of the Indus, in the lower part of its course, is not more than from two to two and a half miles per hour, though the upper portions of its valley are within the highest mountain-region of the globe. The river Colorado, which rises among the western declivities of the Rocky Mountains, at an elevation of 10,000 feet above the sea level, and flows into the Gulf of California after a course of 1,100 miles, is navigable for 500 miles above its mouth, notwithstanding the great amount of fall which belongs to the upper portion of its bed.

9. The current of the Tigris, which rises at an elevation of more than 5,000 feet above the sea, and is traditionally famed for the swiftness of its stream, becomes very moderate below Bagdad, where it is often less than a mile per hour. The rapidity of the stream of the Euphrates varies similarly; in the depressions of the alluvial plain it is often not a mile an hour, while the upper portions of its course average from three to four miles. During the last seven hundred miles of the course of the Amazon, its fall is only twelve inches, or less than one-eleventh of an inch per mile. The Volga, which rises in the plain of Eastern Europe, at the moderate elevation of 633 feet above the Caspian Sea, has an average inclination of less than four inches to the mile throughout its course of more than 2,000 miles. The Rhone, on the other hand, which has its origin among the glaciers of the Alps, at a height of 5,900 feet, passes thence to the Lake of Geneva through a difference of level amounting to 4,670 feet within a course of little more than a hundred miles. The river Dee, which rises at a height of 4,060 feet—probably a greater elevation than that of any other river in the British Islands—has a course of only eighty-seven miles to its outlet in the German Ocean, at the city of Aberdeen, showing an average declivity of 46 feet per mile.

1 An able writer remarks that the velocity of a river does not "depend entirely 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 windings of the course, and the changes in the width of the channel."
10. **Volume.**—The *volume of water* which rivers contain varies with many conditions, dependent upon the nature of the sources by which they are fed, and the amount of rain-fall which belongs to different portions of their beds. In arid countries the so-called rivers are often mere surface torrents, dependent on the rains, and exhibiting merely the dry beds of water-courses during the season of drought. The "wadies" of the Arabian Desert, and the "creeks" of interior Australia, are of this character. If not wholly dried up, the stream is either diminished during the summer, under such circumstances, to a mere thread, or is converted into a chain of ponds, produced by a small residue of water which remains collected in the deep hollows of its bed.

11. In all warm countries, and especially those that fall within or near the tropics, where the seasons of drought and moisture are clearly defined, the contents of the river-beds undergo periodical fluctuation, with the absence or the abundance of rain. With the rainy season, the stream—swollen not merely by the rain-fall of its own immediate neighbourhood, but by the thousand rills which, from distant high grounds, contribute their water to its tributary channels of supply—overflow its beds, and inundates the adjoining plains. With the recurrence of the dry season, the waters again become confined to the limits of their proper channel. The violence of the rains in tropical countries produces extraordinary differences of this kind within periods of brief duration. In Australia, so great is the rain-fall at particular seasons, and of such sudden violence, as within a few hours to convert every gully into a running stream, and every rivulet into a foaming torrent. The periodical melting of the snows adds greatly, in some cases, to the volume of rivers which have their origin in mountain-regions. The numberless torrents which descend the southern declivities of the Alps, and, with each returning summer, swell the streams of the Po and its chief tributaries, furnish examples of this.

[The transporting power of water is very great, and the torrent-like streams of mountain-lands often effect, by the violence of their sudden floods, great changes in the aspect of the valley through which their waters are discharged. "It has been calculated that a velocity of three inches per second will tear up fine clay, that six inches will lift fine sand, eight inches sand as coarse as linseed, and twelve inches fine gravel; while it requires a velocity of twenty-four inches per second to sweep angular stones of the size of a hen's egg." In the interior of the Australian continent, the beds of water-courses which are dry during half the year display evidence of the violence of the winter's flood in the masses of rock torn from the sides of their beds, and strewn along the valley.]

12. **Facilities for Navigation.**—The capability of rivers for navigation, and their consequent use as channels of inland traffic, together with the facilities of ingress and egress to shipping presented by their embouchures, are considerations possessed of the highest importance, in so far as direct utility to man is concerned.
13. Measured by such regards, mere length of channel constitutes an imperfect standard by which to judge of a river's importance. Several among the great rivers of the Asiatic and African continents, owing to their fluctuating volume of water, to the presence of "bars" which obstruct their entrance, or to other causes, are of less service to man than many streams which make an insignificant appearance upon the map of the world. In the giant streams of the New World, we meet, indeed, with examples of rivers whose navigable qualities extend through nearly the whole length of their amazing development. The Amazon is navigable by large vessels for a distance of 2,000 miles above its outlet, and by vessels of smaller size, drawing not more than five or six feet of water, to the very foot of the mountain-region—a further distance of a thousand miles. The Mississippi is navigable for nearly 3,000 miles by the direct arm of the river, and by the Missouri branch to the Great Falls by which it leaves the Rocky Mountains—a distance little short of 4,000 miles from the Mexican Gulf.

[In all social and commercial regards, the Thames, the Mersey, and the Hudson, rank among the most important rivers of the globe. The commercial greatness of the British metropolis, of Liverpool, and of New York, is indissolubly connected with the streams upon which they respectively stand, the broad and deep outlets through which these reach the sea, and the capacious and secure harbours which they consequently form.]

14. The Bore.—The phenomenon of the bore or egré, which in many instances occurs at the mouths of rivers, demands a brief notice. This consists in a tidal wave, which, under certain conditions, rolls up the channel of the river with a velocity so great as to overpower the descending stream, advancing in many cases with a noise like the rolling of distant thunder, and not unfrequently occasioning serious destruction to any shipping that is exposed to its influence.

15. In the case of some rivers, the bore forms a head-wave which rises far above the ordinary level of the stream, and rolls on with irresistible force. The Indus is a conspicuous example of this phenomenon. On a scale of less extent, the Solway Firth, the estuary of the river Severn, and the mouth of the Trent, exhibit like instances on our own coast. The estuary of the river upon which the Chinese city of Hang-chow is situated, exhibits this phenomenon, at the period of the autumnal equinox, in almost unexampled grandeur. "Imagine an estuary four or five miles in width, the tide rising, and at first presenting the appearance of a white line, and gradually approaching with the noise of thunder, and by degrees rising until it becomes a wall four or five miles across, and twenty feet in height, coming up almost with the velocity of a cannon ball." The vast amount of shipping-craft belonging to Hang-chow are obliged to put out into the stream to meet the egré, for if they were to remain in-shore they would infallibly be crushed; when they meet it, they rise over the advancing wave, and escape the temporary danger. The egré is spent about ten miles above Hang-chow.

1 At spring-tides there is a very strong bore in the Trent, the water rising at its mouth to the height of six or eight feet above the ordinary surface, and rolling in a large mass up the river.
16. In the Western World, the giant river Amazon offers a parallel (perhaps even superior) example of the phenomenon, there known as the píroróco. In winter, when the spring-tides are highest, the píroróco breaks with terrific force, often sinking or dashing to pieces boats that have been incautiously left in shallow water. The devastation occasioned in its course is seen in the uprooted trees which line the shores of the stream, and the high mud-banks where the earth has been washed away.¹

17. Classification of Rivers.—The broad division of the rivers of the globe into those which enter the ocean either directly or indirectly, and those which have no outlet to the sea, forms the basis of the general classification of rivers into oceanic and continental. Both oceanic and continental rivers may be arranged into systems, according to the oceanic or continental basins to which they belong.

18. Oceanic River-Systems.—Of the four great oceanic basins, the Atlantic and Arctic receive by far the larger portion of the running waters of the globe. This naturally results from the longer slopes of the land being directed thitherward. Nearly all the longer rivers of the New World, and a considerable number of those of the Old World, flow either into the Atlantic and its gulfs, or into the contiguous basin of the Arctic Ocean. A much smaller number of rivers belong to the Pacific basin; but the least extensive in area of drainage is the basin of the Indian Ocean. Each of these oceanic river-systems is naturally divisible into sections, according to the continent to which they belong. Thus the Arctic river system naturally resolves itself into three sections—the European, Asiatic, and American. The Atlantic system is similarly divisible into four sections; the Pacific into four; and the Indian (Ocean) system into three.

19. The Arctic River-System.—The Arctic Ocean receives the drainage of an immense extent of land, comprising the whole of the Asiatic Continent north of the Stanovoi and the Altai Mountains; Europe, north of latitude 60°; North America, west of a low watershed running from Boothia south-west to Lake Athabasca and the Rocky Mountains. The Arctic system thus embraces three sections—the European, Asiatic, and American.

¹ Wallace: Narrative of Travels on the Amazons and River Negro.—The explanation ordinarily given of the bore, which refers it to the meeting of the tidal and fresh-water currents—a contest between the sea god and the river god—is not strictly correct. The phenomenon is simply due to the strength and velocity of the wave engendered by the flood-tide, obstructed by the resistance occasioned by shoals at the entrance of the stream. When the tides are low, or the entrance of the river very deep, no obstruction to the flow of the tide-wave ensues. It is only in cases where there is a peculiar formation of the bottom, and not merely a narrowing and widening in the channel of a tidal stream, that the bore is occasioned.
20. The European Section of the system is extremely limited—the streams which belong to it being few in number, and of no great importance. The Onega issues from the north-eastern extremity of Lake Latcha, and flows north into the White Sea. It has no connection with the large lake of the same name, which is drained by the Svir into Lake Ladoga. Numerous falls and rapids render the regular navigation of the Onega impracticable, though much timber is floated down the stream in spring. The Dwina, or Dvina, is formed by the union of two branches—the Soukhona, which rises near Vologda, and the Vychegda, which flows from the Timon hills. The general course of the Dwina is to the north-west, falling into a gulf of the White Sea, about 20 miles below Archangel. Its current is gentle, and its navigation is for the most part unimpeded by either shallows or rapids. Frozen over for half the year, its commercial importance is limited; but the timber, grain, and other produce of its basin, is not exclusively exported from Archangel, as its chief tributaries are connected by a system of canals with the Neva, Kama, Volga, &c.—thus forming an uninterrupted waterway between the White Sea and the Baltic, and the Black Sea and Caspian. The Mezen rises in the Timon range, which separates its basin from that of the Petchora. It enters Mezen Bay after a circuitous course through desolate plains and marshes. But by far the longest stream of the section is the Petchora, which is the only considerable European river that falls directly into the Arctic Ocean. It rises on the western slope of the Ural Mountains, which form the eastern limit of its basin, and flows successively through dense forests, barren plains, and frozen marshes. About 700 miles of its lower course are navigable; but it is open only for three months in the year.

21. The Asiatic Section of the Arctic system embraces the whole of the rivers which drain the northern slope of the continent. Rising in the mountain-ranges that form the northern buttress of the great central table-land, the three great rivers of Siberia flow through vast plains, barren and uncultivated or covered with dense forests, becoming more and more barren as they ap-
RIVERS.

...proach the shores of the Polar Sea, where they form the desolate 'Tundras,' a vast tract nearly 4,000 miles in length, alternately an irreclaimable swamp or a frozen plain. Perfectly open to the icy blasts from the north, these rivers are frozen over for several months in the year, and flowing as they do from warmer to colder regions, their upper courses are liberated from the ice, while their middle and lower courses are still frozen. Hence the periodical floods which inundate this inhospitable region. Except when in flood, the slight fall of the land renders them extremely sluggish, but they are not much navigated, except in their upper portions. The Obi may be said to rise in the alpine lake of Toleskoi, in the Altai mountain-region. Flowing generally north-west, it receives the Katunia and the Tom, and, lastly, the great affluent of the Irtish, which, according to the ordinary rule of river-nomenclature, should have been called the Obi. The Irtish rises in the Great Altai, and flowing through Lake Zaisan, receives two large tributaries—the Ishim, from the Kirghiz Steppe, and the larger stream of the Tobol, from the Ural Mountains. After its junction with the Irtish, the Obi repeatedly divides into several channels, and finally enters the Gulf of Obi by three mouths, which are closed with ice from October to May. The Yenesei is formed by numerous streams which descend from the Altai Mountains, and flows almost due north, for the most part between the 85th and 95th meridians E. It receives three larger tributaries on its right bank, known as the Upper, Middle, and Lower Tungouska. The Upper Tungouska, or Angara, drains Lake Baikal, the main feeder of which is the Selenga. The upper courses of the main stream and its tributaries are swift torrents, becoming sluggish and navigable after entering the plain. The main stream is generally of great breadth, and in the lower part of its course is from 12 to 50 feet deep. Like the other Siberian rivers, the Yenesei is subject to annual floods, and is similarly frozen for many months. The Yenesei is now regularly navigated during the summer months by steam vessels. The Lena rises in the mountains that skirt the western shores of Lake Baikal, and almost immediately becomes a navigable stream. It flows first north-east as far as Yakutsk, where it bends north, entering the ocean by several mouths, forming a delta upwards of 100 miles across. Like the Yenesei, it receives three large tributaries on its right bank,—the Vitim, Olekma, and Aldan. Below its junction with the latter it also receives a considerable from the west—the Vilni. Between the lower courses of the Lena and the Yenesei are the minor basins of the Olenek and Katanga. The current of the Lena, except when in flood, is sluggish, and it is much navigated during the brief summer of these high latitudes; remains of the huge mammoth and other animals now extinct are found embedded in its frozen banks, and whole carcases, in almost perfect preservation, are occasionally exposed by the floods. East of the Lena, and separated from it by a low range of hills, are the basins of the Iana, Indigirka, and Kolyma, all of which have a northerly course through the inhospitable Tundras to the sea. The Iana falls into the sea opposite the Liakhov Islands; the Indigirka divides into several channels, which form a small delta; while the Kolyma, the most easterly of the larger Siberian rivers that enter the polar sea, discharges a considerable volume of water by a wide estuary, of sufficient depth to admit the largest vessels.
The American Section comprises one great river, the Mackenzie, and several smaller ones, such as the Colville, Coppermine, and Back’s River. In common with those which fall into Hudson Bay, and therefore belong to the Atlantic river system, these rivers drain a vast region, covered in the south with extensive forests, alternating with open prairies, and passing towards the north into a dreary and barren wilderness, thus approximating in character the desolate wastes of the polar belt of Siberia. The Siberian rivers, however, have well marked basins, and drain but few lakes, while most of the American rivers are connected together by transverse streams, and drain a vast number of lakes and swamps. The water parting between the Arctic rivers and those belonging to the basin of Hudson Bay may be roughly marked by a line drawn from Boothia Peninsula to Lake Wollaston, and thence to Mount Hooker, in the Rocky Mountains. This line, for the most part, scarcely rises above the adjoining ground. Indeed, the two basins are to a large extent continuous, especially in the vicinity of Lake Wollaston, from which one stream flows north into Lake Athabasca, while another runs south into Deer Lake. The Colville, an unimportant and but little known stream, falls into the ocean about 180 miles east of Cape Barrow. The Mackenzie (so called from Alexander Mackenzie, who first discovered and navigated it in 1789) is one of the longest rivers of the globe; its remotest sources—the Athabasca and Peace rivers—rising in the Rocky Mountains, at a distance of more than a thousand miles from the shores of the Polar Sea. The Athabasca rises near the foot of Mount Brown, on the eastern side of the chain, and flows north into Lake Athabasca; the Peace River is on the western slope of the range, and, breaking through it, joins the Slave River, which carry the surplus water of Lake Athabasca into the Great Slave Lake. From the western extremity of the latter a broad stream—the Mackenzie proper—sweeps to the north-west, receiving on its way the An Liard, or River of the Mountains, from the Rocky Mountains, on the left, and the Bear River, from the Great Bear Lake, on the right; finally pouring its vast volume of water into the Polar Ocean by numerous mouths, which enclose a delta 90 miles long, and from 15 to 40 miles broad. The Mackenzie and its tributaries, together with the vast lakes with which they are connected, are for the most part navigable, but the main stream, from the Great Slave Lake to the sea, is closed by ice for nine months in the year, and even the larger lakes are completely frozen over for more than half the year. Extensive deposits of lignite are found along the banks of the Mackenzie, but as yet furs form the sole exportable produce of the vast region through which it flows. The rocky region east of the basin of the Mackenzie is drained by several streams, of which the most considerable are the
Coppermine and Back's River. The Coppermine rises about 50 miles north of Lake Aylmer, and falls into the western extremity of Coronation Gulf. Back's River rises in a small lake close to the northern shores of Lake Aylmer, expands into Lakes Pelly and Garry, and enters an inlet leading into Ross Strait. Both rivers are rapid, and their courses are obstructed by numerous falls and shallows, while the region through which they flow is even more desolate and inhospitable than that drained by the Mackenzie.

23. The Atlantic River-System.—This system, comprising the whole of those rivers which discharge their waters, either directly or indirectly, into the Atlantic Ocean, is pre-eminently the river-system of the globe—far exceeding the other great oceanic systems in the number and magnitude of its rivers, and in extent of drainage-area. The position of the great watersheds of North and South America on the one side, and Europe and Africa on the other, determines the course of a vast number of streams into the basin of the Atlantic, either directly, or indirectly through its numerous inland seas. Thus the drainage area of the Atlantic is estimated at 19,050,000 square miles—nearly $2\frac{1}{4}$ times that of the Pacific, or more than three times that of the Indian Ocean. This system is naturally divided into four sections—the European, African, North American, and South American. Of these the European section is, socially and commercially, the most important; but none of its streams approximate in length or volume the vast rivers of the other great divisions of the globe.

24. The European Section includes the rivers that flow over the northwestern slope of the continent—either directly into the Atlantic, or into the North Sea and the Baltic, and those which drain its south-eastern slope into the Mediterranean and Black Seas. With the exception, therefore, of the few streams that enter the White Sea, Arctic Ocean, and the Caspian, all the European rivers belong to the Atlantic river system. Besides the strictly continental rivers, we have also an insular system, comprising the various streams of the British Islands, none of which are remarkable as regards length or volume, but some of which are, in other respects, far more important than continental rivers of immensely greater magnitude. We shall, therefore, first notice the principal British rivers.
25. As all the higher grounds of Great Britain lie nearer the western than the eastern coast, most of the larger rivers are on the eastern side of the island, and flow into the North Sea. Thus we have the Thames, Trent, and Ouse, in England; and the Tweed, Forth, Tay, and Spey, in Scotland. On the western side of the island there are only three important streams—the Severn and Mersey, in England; and the Clyde, in Scotland. In Ireland the higher elevations are for the most part ranged along the coast: the only considerable stream is the Shannon.

26. The largest and most important river of Great Britain is the Thames, which rises in the Cotswold Hills, in Gloucestershire, and runs east past Oxford, Reading, Windsor, London, Woolwich, and Gravesend, entering the sea by a wide estuary. The moderate elevation of its sources, and its slight fall, renders the current of the Thames extremely gentle, and consequently navigable for smaller craft almost to its source, while the larger vessels ascend it nearly to London Bridge, 60 miles from the sea. Here it is 870 feet wide, and about 12 feet deep. The tide rises from 17 to 22 feet, and is felt at Teddington, twenty miles further up the stream. The upper and middle course of the Thames is through a rich agricultural district, and as far as London its banks are extremely beautiful and diversified; from London to the sea it is probably the most frequented waterway on the globe. The customs receipts amount to upwards of £10,000,000 a year, which exceeds the total receipt at all the other ports of the kingdom, and more than five times that of the whole of Ireland. Of its numerous tributaries the principal are—the Windrush, Evenlode, Thame, Colne, Brent, Lea, and Roding on the north, and the Kennet, Loddon, Wey, Mole, Darent, and Medway on the south. The Ouse, sometimes distinguished as the Yorkshire Ouse, is formed by the junction of the Swale and the Ure, both of which rise in the Pennine Range. It becomes navigable at York, and enters the Humber. The Trent rises in the moorlands of Staffordshire, and is navigable for vessels of 200 tons to Gainsborough, and for barges to Burton, 105 miles from its confluence with the Humber. The Humber is a broad channel, but its navigation is impeded by numerous shallows and sand-banks, and the rapid ingress of the tidal wave forms a dangerous bore or "ægre." The Tweed is a swift and unnavigable stream, noted only for its salmon fisheries. The Forth rises in a spring at the foot of Ben Lomond, and at Alloa falls into the broad and deep firth to which it gives its name. But the largest river of Scotland is the Tay, which carries more water to the sea than any other British river. It becomes navigable at Perth, and terminates below Dundee by a wide estuary.

27. On the western side of England, the Severn exceeds the Thames in length, but its drainage area is not so extensive. Rising in the moors on the eastern side of Plinlimmon, it flows through a gradually widening valley, describing almost a semicircle, widening tortuously between Gloucester and Berkeley, and emptying itself by a broad estuary into the Bristol Channel. It receives most of its tributaries from the Welsh Mountains, and is navigable to Welshpool, 170 miles from the sea. The tidal wave rushes up the Channel with great force, and rises at Chepstow to a height of 60 feet. The most considerable of the streams that enter the Irish Sea is the
Mersey, whose "basin resembles a vast workshop, so numerous and so close together are the manufacturing towns," and whose estuary forms the "Liverpool Channel." On the western side of Scotland the only large stream is the Clyde, whose basin is also a most important industrial centre. The Clyde rises in the Lowthers, and winds through a hilly and picturesque district, descends 230 feet in three falls near Lanark, becomes navigable at Glasgow, the chief port of Scotland, and below Greenock enters a broad firth. Of the Irish rivers the principal is the Shannon, which rises at the foot of the Cuilcagh hills, in Cavan, and flows south-west into the Atlantic, through a generally level district, expanding in its course into three lakes, two of which, Ree and Derg, are of considerable extent. It is navigable to Lough Allen, that is, within seven miles of its source. The falls, or rather rapids, of Doonass, near Limerick, where the river "rolls tumultuously over a succession of rugged rocks," are avoided by a lateral canal. Two great canals connect the Shannon with Dublin. The tide rises from 14 to 18 feet, and sweeps rapidly up the long estuary.

### Atlantic River-System.—European Section.

<table>
<thead>
<tr>
<th>Name</th>
<th>Length</th>
<th>Area of Basin</th>
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</thead>
<tbody>
<tr>
<td>Torne</td>
<td>350</td>
<td>16,000</td>
</tr>
<tr>
<td>Dal</td>
<td>350</td>
<td>11,600</td>
</tr>
<tr>
<td>Neva</td>
<td>40</td>
<td>91,000</td>
</tr>
<tr>
<td>Dwina</td>
<td>550</td>
<td>45,000</td>
</tr>
</tbody>
</table>

28. Having thus briefly sketched the British river-system, we proceed to notice in detail the other chief European rivers belonging to the Atlantic system. These we may arrange in seven groups, distinguishing the rivers flowing into (1) the Baltic; (2) the North Sea; (3) English Channel; (4) Bay of Biscay; (5) the Ocean directly; (6) the Mediterranean; and (7) the Black Sea.

29. Of the rivers that flow into the Baltic on the west, the most considerable are the Torne and Dal, between which—a distance of less than 500 miles—no less than seven streams, each upwards of two hundred miles in length, descend from the inland mountain-region to the sea. All these rivers preserve a remarkable parallelism from their sources to the sea—their direction being for the most part south-east. They also expand, especially in their upper courses, into narrow lakes, and are frequently interrupted by falls and rapids, which render them of little use besides floating the timber felled in the interior forests to the seaboard. On the east, the short but broad and deep Neva carries a vast amount of water from the great lakes into the Gulf of Finland. Although subject to terrible floods, and obstructed by ice for five months of the year, the Neva is a commercial channel of the highest importance; by means of a system of canals, the Russian metropolis has uninterrupted water communication with Archangel, the chief port of the north, and Astrakhan, the emporium of the Caspian. The Dvina, or Dün, is another important waterway of north-western Russia. It
rises in a small lake 15 miles west of the source of the Volga, flows at first south, then curves west, finally entering the Bay of Riga in a north-westerly direction. The country through which the Dvina flows is perfectly flat, but the navigation of the stream is obstructed by numerous shallows and rapids, some of which are extremely dangerous. Like the Neva, it occasionally rises and inundates the adjoining plain, and it is also frozen over from November to April. The Niemen rises in the marshes of Minsk, and is for the most part a navigable stream—the chief outlet of the trade of Lithuania. It enters the Curische Haff by two mouths. The Szczara, a tributary of the Niemen, is connected by the Oginski Canal with the Pripet, an affluent of the Dnieper. The Vistula rises in the Carpathians, and after an extremely circuitous course through a flat country, enters the sea by several mouths, one of which opens into the Frische Haff. At Cracow the river is about 150 feet across, scarcely a tenth of its width at Warsaw. A short distance below Warsaw it receives the large stream of the Bug. It is navigable to Cracow, and vast quantities of timber and corn are consigned from the interior to Dantzig for export. Its commercial value is considerably augmented by the canals which unite it to the Niemen, Oder, Elbe, and Dnieper. The only other considerable stream belonging to the Baltic basin is the Oder, one of the most important waterways of Germany. The Oder rises in the Sudetes Mountains, and flows first through magnificent forests, and then through a level country studded with lakes and marshes, repeatedly dividing into several channels, forming numerous eyots, and ultimately entering the Bay of Stettin by two mouths. Like the Vistula, it receives its largest affluent (the Warta) from the right. The Oder is navigable for small vessels as far as Breslau, and like the other rivers of the Russo-Germanic plain, is connected by canals with the adjacent streams.

**Atlantic River-System.—European Section.**

<table>
<thead>
<tr>
<th>Name</th>
<th>Length</th>
<th>Area of Basin</th>
<th>Name</th>
<th>Length</th>
<th>Area of Basin</th>
</tr>
</thead>
<tbody>
<tr>
<td>Göta</td>
<td>70</td>
<td>13,700</td>
<td>Rhine</td>
<td>760</td>
<td>88,800</td>
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<tr>
<td>Glommen</td>
<td>400</td>
<td>16,500</td>
<td>Meuse</td>
<td>550</td>
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<tr>
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<td>600</td>
<td>57,000</td>
<td>Scheldt</td>
<td>250</td>
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</tr>
<tr>
<td>Weser</td>
<td>380</td>
<td>17,800</td>
<td></td>
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</tr>
</tbody>
</table>

30. Of the rivers that enter the North Sea, or its gulfs, the principal are—the Göta, Glommen, Elbe, Weser, Rhine, Meuse, and Scheldt. The Göta, like the Neva, is but a short river, draining an inland lake, and has its virtual source in the Klar-elf, the main feeder of Lake Wener. The picturesque Trolhattan Falls, on the Göta, are avoided by a side channel, nearly a mile long, cut in the solid rock. The Göta Canal unites the river Göta with Lakes Wener and Wetter, and thus completes an inland waterway between the Skager-rack and the Baltic. The Glommen is the longest of the Norwegian rivers, and flows rapidly south into Christiania Fiord, at the head of the Skager-rack. It receives a large number of tributaries—one of which, the Vormen, drains Lake Miösen. The
longest of the Danish rivers hardly exceeds fifty miles, and the few streams of Schleswig-Holstein are scarcely superior. Next to the Rhine, the Elbe is probably the most important commercial waterway of Germany. On the main stream, or on some of its numerous tributaries, are several of the largest towns of the empire; and on its estuary, sixty miles from the sea, stands Hamburg, the emporium of the foreign commerce of Germany, and the seat of an immense trade with all nations. The Elbe is said to have its source in thirty springs on the western slopes of the Schneekopf, the highest point of the Riesen-Gebirge. The upper portion of its course is within an elevated quadrilateral, bounded by the Böhmer-Wald and Moravian Mountains on the south, and the Erz and Riesen-Gebirge on the north. Flowing first south, through a narrow and deep valley, it curves gradually to the north-west, and receives numerous affluents. Leaving the Bohemian upland by a narrow defile, formed by the close approach of the Erz and Riesen-Gebirge, it traverses first the hilly region of Saxon-Switzerland, and then a succession of the level plains, ultimately entering the North Sea by an estuary thirteen miles wide at Cuxhaven. Within this portion of its course the Elbe receives the Mulde and Saale on the left, and the Elster and Havel on the right. The Weser is formed by the junction of the Werra and Fulda at Münden. The Werra rises in the Frankenwald, and the Fulda in the Rhon-Gebirge. From Münden the main stream runs north, passing near Minden through a gorge, known as the "Gate of Westphalia," and enters the Jahde by an estuary about forty miles below the great port of Bremen. The Weser is navigable nearly throughout its entire course, but its estuary is so shallow that large vessels load and unload at Bremerhaven, the outport of Bremen. The basin of this river, like that of the Lower Elbe, is flat, sandy, and naturally barren.

31. We now come to the celebrated stream of the Rhine, one of the longest and most important of European rivers. With its numerous affluents the Rhine drains an area of not less than 66,800 miles (more than twice the size of Ireland), of which 10,700 square miles are within Switzerland, 35,400 square miles within Germany, 7,000 square miles within France, and 13,700 within the Netherlands. Physically the basin of the Rhine is divided into three well-defined sections—(1) the Upper Rhine, from the source of the river to Basle, graphically described by Lavallée as "a vast, almost circular tract, surrounded by a dense ridge of mountains, abounding in peaks, lakes, and streams, where there are but few plains, and those very circumscribed in extent, and where the valleys alone open up communication;" (2) the Middle Rhine, from Basle to Wesel, "an immense quadrilateral space comprised between Basle, Wesel, Metz, and Nuremberg, one of the richest and most densely peopled districts in Europe, traversed by mountain chains parallel to the course of the river, the most remarkable of which are the Vosges and the Black Forest, which enclose the Rhine in a long and narrow valley of great fertility and most picturesque appearance; (3) the Lower Rhine, from Wesel to the sea, "broad and level, without enclosing heights, open on every side, covered with water and marshes, broken into fragments by inundations of the sea, and of which the parts near the sea are below the level of high water; the climate unhealthy in many places; the land

* Physical, Historical, and Military Geography (Stanford, London).*
abundantly watered by innumerable canals and streams, almost everywhere fertile and well cultivated.”

32. The Upper Rhine.—The Rhine is formed by the junction of numerous streams rising in the higher portion of the Alps, of which the principal are the Vorder Rhine and the Hinter Rhine. The Vorder Rhine rises in a small lake near Mount St. Gothard, at an elevation of 7,690 feet, and flows north-east through the rugged valley of the Rheinwald, joining the Hinter Rhine at Reichenau. The Hinter Rhine rises in the Rheinwald Glacier at a height of 7,270 feet, and flows first north-east through the magnificent gorge of the Via Mala, and then turns north to join the Vorder Rhine. The now considerable stream flows north-east, bending in the vicinity of Coire (Chur) to the north, flanked on the left by a continuous wall of mountains, and forming part of the boundary between Switzerland and Austria, finally entering the Lake of Constance. A tongue of land bisects the western end of the lake into two basins, from the lower of which the Rhine flows due west, falling below Schafhausen over rocks 65 feet high, and rushing swiftly through a tortuous defile; receiving at Waldshut the Aar, and completing at Basle the upper or first portion of its course. Rising in the glaciers of the Grimsel, the Aar waters nearly the whole of Switzerland between the Bernese and Swiss Alps on the east, and Mount Jura on the west, and carries off the surplus waters of almost all the Swiss lakes, except those of Geneva and Constance. The main stream drains the lakes of Thun and Brienz—its tributaries, the Theile, drains Lake Neufchatel; the Reuss, Lake Lucerne; and the Limmat, Lake Zurich. At Basle the Rhine is 800 feet broad, and 765 feet above the sea, or nearly 7,000 feet lower than the source of the Vorder Rhine.

33. The Middle Rhine.—Leaving Basle, the Rhine turns abruptly north, and flows through a valley bounded by the Schwarzwald on the east, and the Vosges on the left. Between Basle and Strassburg the river is studded with numerous islands, and its current is still rapid. At Mayence it curves west as far as Bingen, through a beautiful, open valley; from Bingen to Coblenz it winds between rugged and lofty hills, frequently surmounted by picturesque ruins and castles, clothed with magnificent forests, or covered with vineyards—forming, indeed, a “blending of all beauties.” From Coblenz to Bonn the scenery is not so wild, but hardly less beautiful; thence it flows through a more level district, and about 30 miles below Wesel enters the low countries. Of the tributaries of the Middle Rhine the more important are the Neckar, Main, Lahn, and Lippe, on the right, and the Ill and Moselle on the left.

34. The Lower Rhine.—Near the Dutch frontier, the Rhine (there 2,000 feet broad) divides into two branches, of which the northern (though by far the smaller branch) retains the name of Rhine; the southern arm, known as the Waal, joins the Maas, or Meuse. The northern stream, under the name of Old Rhine, flows west into the sea by Arnhem, Utrecht, and Leyden; but most of its waters are carried off by the Yssel and Amstel into the Zuyder Zee, and the Lech (the main stream) into the estuary of the Maas. The whole basin of the Lower Rhine is level, and the various branches of the river are embanked by enormous dykes, which alone prevent the waters from inundating the country.
The Rhine is navigable for sea-going vessels to Cologne; small steamers ascend as far as Basle; boats thence to the falls of Schaffhausen, and, beyond, to Chur. But its navigation is everywhere difficult—in the upper basin, on account of the falls; in the middle basin, on account of the islands; and in the lower basin, on account of the want of current. Canals connect the Rhine basin with those of the Rhone, Scheldt, and Danube.

35. Some geographers regard the Meuse, or Maas, as a mere tributary of the Rhine. It rises in the upland of Langres, and flows north, disappearing underground for four miles, near Neufchateau. Below Charlemont it enters Belgium, where it receives the Sambre and the Ourthe, both of which rise in the Ardennes; it then enters Holland at Maestricht, and gradually curves west, joining the Waal at Gorkum, and almost immediately dividing into numerous branches—finally entering the sea by three channels. The Meuse is, throughout the greater part of its course, a deep and navigable stream. The Scheldt, like the Meuse, also has its upper course within France. From its source in the plateau of St. Quentin, its general course is north to Ghent; thence it turns north-east to Antwerp, where it turns north and west. Its estuary, which divides into two channels opposite the mouth of the Thames, is "unequalled for safety and depth." Though short, the Scheldt is, commercially, one of the most important rivers of western Europe, and the lower part of its basin is the most thickly populated region on the continent. Of the numerous streams that fall into the English Channel from the mainland, the only one of importance is the Seine, which waters one of the most fertile districts of northern France. It rises in Mount Tasselot, the culminating summit of the Côte d'Or, at an elevation of 1,426 feet above the sea, and becomes navigable at Troyes—130 miles from its source, and 340 miles from the sea. Flowing generally north-west through a gently sloping valley, it receives the Yonne from the Morran Hills on the left, and the Aube, and (at Paris) the Marne, from the plateau of Langres, on the right. Below Paris its course is extremely tortuous—receives several large tributaries, and at Rouen is sufficiently deep for sea-going vessels; enters the sea by an estuary fifteen miles wide, near the important port of Havre. The slight fall and tortuous course of the Seine renders its current extremely sluggish; below Rouen its channel is obstructed by sand-banks.

**Atlantic River-System.—European Section.**

<table>
<thead>
<tr>
<th>Name</th>
<th>Length</th>
<th>Area of Basin</th>
<th>Name</th>
<th>Length</th>
<th>Area of Basin</th>
</tr>
</thead>
<tbody>
<tr>
<td>4.—Flowing into the English Channel.</td>
<td></td>
<td></td>
<td>6.—Flowing directly into the Atlantic.</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Seine</td>
<td>470</td>
<td>30,000</td>
<td>Minho</td>
<td>200</td>
<td>6,300</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td>Douro</td>
<td>460</td>
<td>39,000</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td>Mondego</td>
<td>120</td>
<td>2,700</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td>Tagus</td>
<td>510</td>
<td>34,000</td>
</tr>
<tr>
<td>5.—Flowing into the Bay of Biscay.</td>
<td></td>
<td></td>
<td>Guadiana</td>
<td>450</td>
<td>26,000</td>
</tr>
<tr>
<td>Loire</td>
<td>570</td>
<td>48,000</td>
<td>Guadalquivir</td>
<td>290</td>
<td>20,000</td>
</tr>
<tr>
<td>Garonne</td>
<td>350</td>
<td>33,000</td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

36. The central and south-western portions of France are watered by numerous streams which fall into the Bay of Biscay, of which the principal are the Loire
and Gironde. The Loire rises at an elevation of 4,556 feet above the sea, in the Gerbier de Joncs, in the Cevennes Mountains, and flows north to Nevers, where it receives the Allier—then bends west, past Orleans and Tours—finally entering the sea by a wide estuary below Nantes. The Loire is navigable for about two-thirds of its total course, but its general shallowness, rapidity of its current, and frequent floods, make its navigation difficult. The basin of the Loire is "the largest and most fertile in France; in the south, narrow and hilly, intersected by rich valleys, and rocky, sterile districts; in the centre, it is made up of low valleys and splendid plains, with tracts of sand and heath interposed; in the west, the country is diversified, rich, fertile, and well cultivated." (Lavallée.) The Garonne rises in the Val d’Aran, in the central Pyrenees, and flows north through defiles and narrow valleys to Toulouse, beyond which it curves gradually north-west, running for the most part through a level and generally fertile country. A few miles below Bordeaux it receives its principal tributary, the Dordogne; the united streams then form an estuary of from two to nine miles broad, known as the Gironde. Though shallow and subject to inundations, both the Garonne and Dordogne are much navigated in their lower and middle courses—their common outlet, the Gironde, is encumbered with islands and sand-banks. Of the rivers that enter the Atlantic directly from the Spanish peninsula, the principal are the Minho, Douro, Mondego, Tagus, Guadiana, and Guadalquivir. The Minho is a small stream draining the mountainous province of Galicia, and forming in its lower course the boundary between Spain and Portugal. The Douro drains the wide and mountainous upland lying between the Asturian Pyrenees on the north, and the Mountains of Castile on the south, and enters the sea below Oporto. Its current is rapid, and its floods frequently most destructive. It is navigated with difficulty for 75 miles above Oporto. The Mondego is the only river in the peninsula that is entirely within Portugal. It rises in the Sierra d’Estrella, which also divide its basin from that of the Tagus, the longest of all the Iberian rivers. Rising in the Sierra Albaracín, the Tagus sweeps through the sandy plain between the Castilian sierras and the Mountains of Toledo, and only becomes navigable in the coast plain, 75 miles from the sea. The middle portion of its estuary forms the magnificent natural harbour of Lisbon. South of the Tagus, and divided from it by the Mountains of Toledo, is the Guadiana, which at a distance of 10 miles from "its source disappears; re-emerging twelve miles lower down in two small lakes; the Los Ojos de Guadiana." It then flows rapidly west to the frontier fortress of Badajoz, where it curves south, becoming navigable at Mertola, 40 miles from the sea. Its basin is bounded on the south by the Sierra Morena; the plain between which and the Sierra Nevada is drained by the Guadalquivir, which enters the ocean 18 miles north of Cadiz. This stream is navigable to Cordova. Below Seville it divides into three channels, enclosing two large islands.

37. Having thus described the chief rivers of Western Europe, we proceed to notice those which enter the Mediterranean and Black Seas. The principal rivers entering the Mediterranean from Europe are the Segura, Xucar, and Ebro: the Rhone; Arno, Tiber, Po, and Adige; and the Vardar, Struma, and Maritsa. An irregular and for the most part considerably elevated line of heights, extend-
ing from Cape Tarifa through the Pyrenees, Cevennes, Alps, Dinaric Alps, and Balkans, to the Dardanelles, enclose the European section of the drainage-area of the Mediterranean. This line is nowhere at any great distance from the sea, consequently the rivers are generally short—only one stream, the Rhone, being upwards of 500 miles in length.

### ATLANTIC RIVER-SYSTEM.—EUROPEAN SECTION.

#### 7.—Flowing into the Mediterranean.

<table>
<thead>
<tr>
<th>Name</th>
<th>Length</th>
<th>Area of Basin</th>
<th>Name</th>
<th>Length</th>
<th>Area of Basin</th>
</tr>
</thead>
<tbody>
<tr>
<td>Segura</td>
<td>200</td>
<td>6,500</td>
<td>Po</td>
<td>450</td>
<td>40,000</td>
</tr>
<tr>
<td>Xucar</td>
<td>250</td>
<td>6,400</td>
<td>Adige</td>
<td>250</td>
<td>5,600</td>
</tr>
<tr>
<td>Ebro</td>
<td>420</td>
<td>34,000</td>
<td>Vardar</td>
<td>200</td>
<td>9,500</td>
</tr>
<tr>
<td>Rhone</td>
<td>530</td>
<td>38,000</td>
<td>Struma</td>
<td>250</td>
<td>7,400</td>
</tr>
<tr>
<td>Arno</td>
<td>150</td>
<td>2,900</td>
<td>Maritza</td>
<td>320</td>
<td>17,500</td>
</tr>
<tr>
<td>Tiber</td>
<td>210</td>
<td>6,300</td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

38. The Segura rises in the Sierra de Sagra, and winding eastwards, receives at Murcia its chief tributary, the Sangonera, from the south. Its upper basin is a bare rugged upland—its lower course lies through a fertile, well cultivated plain. The Xucar rises in the Sierra Albaracin, and flows first south, then tends east, entering the sea about 15 miles below Alceira. The north-eastern portion of Spain is drained by the Ebro, the longest, but also the shallowest, river of the peninsula. It rises in the Cantabrian Mountains, and flows south-east through narrow valleys, tortuous ravines, and formidable defiles, entering the sea by several mouths, which enclose a large delta. Its current is rapid, and its course so frequently interrupted by rocks and shallows, that, were it not for the lateral canals, its middle basin would be inaccessible by water. It is, besides, subject to floods. The Rhone rises in the Rhone Glacier, on the west slope of Mont St. Gothard, at an elevation of 5,500 feet, about 18 miles from the source of the Vorder Rhine. It flows first south-west through a wild and picturesque valley, flanked by the stupendous chains of the Pennine Alps on the south, and the Bernese Alps on the north. At Martigny it turns north, and enters the Lake of Geneva, laden with a vast amount of sediment, the constant deposition of which must ultimately fill up the lake. Leaving the lake at Geneva beautifully clear, it is almost immediately joined by the muddy stream of the Arve, from the Valley of Chamouni; it then flows south and west to its confluence with the Saone at Lyons. The Saone rises in the plateau of Langres; it receives a large stream, the Doubs, from the Jura. The united stream then flows south through a populous and well-wooded country to Arles, where it divides into two branches, finally entering the sea by four mouths. The Rhone is navigable from the Lake of Geneva to the sea, but its steep fall renders its current extremely rapid: it is, in fact, "the most impetuous river in Europe." In the northern and wider part of peninsular Italy, the Apennines closely approximate the eastern coast; the longest rivers are therefore on the western side. But none of them are of any considerable importance in a merely geographical
sense, though of great historic fame. The Arno rises in Monte Falterona, in the Tuscan Apennines, at an elevation of 4,429 feet, and flows first south-west between the main chain and one of its lateral ridges; then bends abruptly west, and flows through Florence, terminating below Pisa. Its valley is, except near the sea, one of the richest and most fertile in Italy. It is connected by the Chiano Canal with the Tiber. Being subject to floods, it has in some parts been embanked; when in flood it carries down large quantities of mud and other débris. The Tiber also rises in the Tuscan Apennines, about 25 miles east of the source of the Arno, and runs south through Umbria, bending south-west through the Roman territory, and falling into the sea at the once important, but now decayed, port of Ostia. The Tiber is historically the most famous river in Europe—16 miles above its mouth stands the celebrated City of Rome. It is deep, but rapid, and navigable only for 90 miles from the sea. But the longest, and geographically the most important, Italian river is the Po, which drains the plain of Lombardy, one of the most beautiful, fertile, and thickly peopled districts in Europe—most appropriately called the "Garden of Europe," enclosed on the north and west by the snowy ranges of the Alps, and on the south by the less elevated range of the Apennines. The Po rises in Mont Viso, the culminating summit of the Cottian Alps, descends swiftly into the plain, receives numerous tributaries from the Western Alps, bends east at Turin, receives on the left the Ticino from Lake Maggiore, the Adda from Lake Como, the Oglio from Lake Iseo, and the Mincio from Lake Garda, and on the right the Trebbia, Panara, Reno, &c., from the Apennines. By the melting of the snow on the Alps the volume of the river is so augmented that, were it not for the embankments, the adjacent plain would be inundated; the vast quantities of mud it carries down has so accumulated at its mouth, that the old Roman seaport of Adria, which gave its name to the Adriatic Sea, is now more than fifteen miles inland. A large proportion of the sediment washed down from the mountains does not reach the sea, and thus the bed of the river has been gradually raised above the adjoining plain. At Ferrara the streets of the town are said to be 30 feet below the surface of the river. The floods occur "two or three times in the year, last from 30 to 40 days, quadruple the height of the river; the inhabitants on these occasions hasten to the dykes to strengthen them; but their efforts must some day prove insufficient, and the low part of the basin of the Po will become an immense marshy lake, in which the mouth of the river will be lost"—(Lavallée.) The Po is navigable for nearly 300 miles, but its frequent and sudden changes in depth and velocity render its navigation dangerous, and it is chiefly of service for irrigation, for which it is peculiarly adapted by reason of the elevation of its channel. The adjacent stream of the Adige is somewhat similar in character to the Po. Rising under the name of Etsch in the Rhaetian Alps, it flows through the wild valley of Vintschgau, and after receiving the Eisach from the Brenner Pass, turns south through the mountainous region of southern Tyrol, enters the Italian plain below Rivoli, bends south-east at Verona, and falls into the Adriatic a few miles north of the principal mouth of the Po. The Adige is deep and broad, but the rapidity of its current, and its frequent floods, greatly obstruct its navigation. Its lower course is embanked, and it is connected with the lower Po by several branches and canals.
39. Of the streams of the Balkan peninsula, those that drain the western slope to the Adriatic and Ionian are mere mountain-torrents: the country east of Mount Pindus and south of the Balkans is watered by several considerable streams, the principal of which are the Maritza, Vardar, and Salembria. The Maritza rises in the Balkans, and drains the region enclosed by the Little Balkan on the east, the Balkans on the north, and the Despoto Dagh on the west. It is navigable for small vessels in winter and spring as far as Adrianople. The country between the Despoto Dagh and the Pindus is drained by the parallel streams of the Kara-su, Struma, Vardar, and Indjeh, none of which admit of navigation. The fertile plain of Thessaly, now a part of the kingdom of Greece, is watered by the Salembria, which rises in the Pindus, and turning north-east at Larissa flows through the beautiful valley bounded by the famous heights of Olympus and Ossa, into the Gulf of Salonica.

40. Owing to the close proximity of the great ranges which form the boundaries of the European section of its basin, the Mediterranean, notwithstanding its vast extent, receives the drainage of a comparatively small portion of Europe—not more than 300,000 square miles, only a twelfth part of the total area of the continent. But the adjacent basin of the Black Sea, though much smaller than the Mediterranean, receives the drainage of an area three times as large—estimated at 900,000 square miles, or nearly a fourth of the entire area of Europe. Indeed, the drainage area of one of the rivers that fall into the Black Sea, the Danube, exceeds by 10,000 square miles the total area drained by all the European streams which fall into the Mediterranean. And of the other river-basins which incline to the Black Sea, and its extension the Sea of Azov, two—those of the Dnieper and Don—have each an area of more than 200,000 square miles.

<table>
<thead>
<tr>
<th>Atlantic River-System.—European Section.</th>
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<tbody>
<tr>
<td><strong>NAME</strong></td>
</tr>
<tr>
<td>8. Flowing into the Black Sea—</td>
</tr>
<tr>
<td>Danube</td>
</tr>
<tr>
<td>Dniester</td>
</tr>
<tr>
<td>Dnieper</td>
</tr>
<tr>
<td>Kouban</td>
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<tr>
<td>9. Flowing into the Sea of Azov—</td>
</tr>
<tr>
<td>Don</td>
</tr>
</tbody>
</table>

41. The Danube is the second largest river of Europe. Its basin, which is bounded on the north by the Hercynian Mountains, the Carpathians, and the low hills between the Pruth and the Dniester on the north, and the Alps and the Balkans on the south, is naturally divided into four main sections by three transverse ranges, through which the river passes by narrow defiles of considerable length. The first section forms a moderately elevated plateau; the second is generally level on the left, but hilly on the south; the third and fourth sections
are immense plains. The first section of the Danube extends from its source to its confluence with the Inn. It is formed by the junction of two streams, the Brege and the Brigach, which rise in the Schwarz Wald, at an elevation of 2,237 feet; locally, it is considered to originate in a spring in the garden of Donaueschingen Palace. It then flows through a succession of narrow valleys and defiles to Ulm, where it becomes navigable at a height of 1,400 feet above the sea. It next traverses the broad upland of Bavaria, receiving the Altmühl and Naab on the left, and the Lech, Isar, and Inn on the right. The Inn rises in a small lake in the Rhaetian Alps, and flows through the romantic valley of the Engadin, falling into the Danube at Passau. Below Passau it enters a defile formed by the approach of the Bohemian Mountains and a spur of the Noric Alps, thus completing the first section of its course. The second section extends from this defile to a similar but longer ravine between Gran and Waitzen, formed by the converging part of the Bakony Forest and the Matra Mountains. Between Linz and Vienna its channel is often of great width, and studded with islands; below Vienna it divides repeatedly, forming several islands of considerable extent. From the hilly region on the right it receives numerous tributaries, but none of any considerable length; on the left, the level and open country between the Moravian Mountains and the Little Carpathians is drained by the March, while the Waag and Gran water the valleys between the Little Carpathians and Mount Matra. This portion of the Danube basin is fertile and well cultivated, and rich in minerals. The third section of the basin of the Danube forms the Great Plain of Hungary, which is nowhere more than 400 feet above the sea level. At Waitzen the Danube bends abruptly south by Buda-Pesth, the Hungarian metropolis; repeatedly divides into several branches, and at its confluence with the Drave turns east, receives the Theiss on the left, and the Save and Morava on the right, entering at Moldava the third and last defile; the narrowest portion of which, below Orsova, forms the famous “Iron Gate,” a deep gorge, nearly a mile in length, through which the river rushes rapidly and tumultuously. The greatest affluent of the Danube, the Theiss, rises in Mount Galatz, in the Carpathians, and receives among other streams the Maros, which drains the Transylvanian highlands. The Drave rises in the Noric Alps, the Save in Mount Terglou in the Julian Alps, and the Morava in the Balkans. Leaving the Iron Gate at Gladova, the Danube enters the fourth and last section of its basin, which is also level near the river, but becomes more elevated and broken towards the Carpathians on the north, and the Balkans on the south. Its course from Gladova is south-east to Widin, where it bends east, turning at Rassova due north to Galatz, where it again turns east, entering the Black Sea by several mouths, of which the most important are the Kilia, the Sulina, and the St. George’s. The most considerable tributaries of the lower Danube are all on the left bank, and these are the Aluta, Prahova, Sereth, and Pruth, all rising in the Carpathians. On the right it is joined by numerous streams from the Balkans, the largest of which is the Isker. The Danube is now navigable for steamers from Ulm to the sea, and is probably the most important commercial waterway on the continent. Its upper portion is always, and its lower portion occasionally, frozen over in winter. It is estimated to discharge into the sea 20,000,000 cubic feet of water per minute; that is more than all the other rivers that
enter the Black Sea taken together. It also brings down a vast amount of sediment; its delta is estimated to have advanced six miles since the year 800.

42. The Dniester rises on the northern slopes of the Carpathians, and flows first through a narrow wooded belt, then through vast, treeless plains. Although its course is tortuous, its average fall is considerable, consequently its current is rapid. Several rapids and shallows make its navigation difficult. Occasionally the water is so low that boats only can be used. The average depth of its principal mouth is only $2\frac{1}{2}$ feet. Vessels reach the main stream from the sea by an adjacent river and canal. The navigation of the parallel stream of the Boug is obstructed by rocks and sand-banks. This river enters the estuary of the Dnieper a few miles below Nikolaev. The Dnieper rises in the marshes near the foot of the Valdai Hills, not far from the banks of the Volga, and flows first west by Smolensk, where it becomes navigable, then south through an undulating and fertile plain, bending at Kiev to the south-east as far as Ekaterinoslav, where it turns south and south-west, finally terminating by a wide estuary below Kherson. Of its tributaries the principal are—on the right, the Pripiet, which rises in and drains the most extensive marshes in Europe; and on the left, the Desna, which joins the main stream at Kiev. The navigation of the Dnieper is interrupted below Ekaterinoslav by several dangerous rapids. At Kiev the river is icebound on an average for 98 days in the year, and at Kherson for 80 to 85 days. It is connected by canals with the Dvina, Niemen, and Vistula. The region between the Dnieper and the continental stream of the Volga, consisting of a moderately fertile plain in the north, and an arid, treeless steppe in the south, is drained by the Don, which rises in Lake Ivan, from which another stream joins the Oka, an affluent of the Volga. The average fall is slight, amounting to little more than 5 inches per mile. In spite of numerous shallows, it is regularly navigated by small vessels, except from November to March, when it is icebound, and in August, when the water is extremely low. It falls into the Sea of Azov by three mouths, only one of which is navigable. Its chief affluent is the Donetz. The shallow but rapid stream of the Kouban rises on the northern slopes of the Caucasus at an elevation of 14,000 feet, and discharges its waters by two mouths, one of which enters the Sea of Azov, and the other a small inlet of the Black Sea.

<table>
<thead>
<tr>
<th>Name</th>
<th>Length (Miles)</th>
<th>Area of Basin (Sq. m)</th>
</tr>
</thead>
<tbody>
<tr>
<td>10. — Flowing into the Black Sea.</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Kizil-Irmak</td>
<td>500</td>
<td>30,000</td>
</tr>
<tr>
<td>Yeshil-Irmak</td>
<td>200</td>
<td>—</td>
</tr>
<tr>
<td>11. — Flowing into the Mediterranean.</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Mendere</td>
<td>230</td>
<td>7,500</td>
</tr>
<tr>
<td>Sihun</td>
<td>250</td>
<td>6,000</td>
</tr>
<tr>
<td>Jihun</td>
<td>250</td>
<td>7,800</td>
</tr>
<tr>
<td>Orontes</td>
<td>200</td>
<td>4,500</td>
</tr>
</tbody>
</table>
43. The Asiatic Section of the Atlantic, or rather Mediterranean, river-system, embraces numerous unimportant streams that fall into the Black Sea, the Ægean, and the Mediterranean, from Trans-Caucasia and Asiatic Turkey. Of the Trans-Caucasian rivers the only noticeable one is the Rion, which rises in the Caucasus, and flows west past Kutais, entering the sea at Poti. This stream was regarded by the ancients as the boundary between Europe and Asia. The interior plateau of Asia Minor is dry and sterile, and the numerous streams that descend thence to the sea are mere torrents—rapid and unnavigable. The northern slope is drained by the Yeshil-Irmak, the Kizil-Irmak, and the Sakaria, and other smaller streams, all of which rise in the interior highland, and pass through deep narrow valleys and rugged defiles to the sea. The Kizil-Irmak (ancient Halys) describes a curve more than three times the direct distance from its source to its mouth. Although it is the largest river in the peninsula, its elevated sources, steepness of its bed, and small volume of water, combine to render it useless for the purposes of navigation. The streams that fall into the Sea of Marmora and the Dardanelles are small and unimportant. Those entering the Ægean Sea are more considerable. Of the latter the principal are Bakyr Tchai, Gediz Chai, Kuchouk Mondere, and Mondere Chai, better known by their ancient names of Caicus, Hermus, Cayster, and Meander. These rivers flow through long and (except towards the sea) narrow and fertile valleys, of alluvial formation. Like all the other streams of Anatolia, they carry down vast quantities of earthy matter, so that many ancient ports and former inlets are now entirely blocked up. At the present time the Hermus is fast silting up the Gulf of Smyrna. On the south, the streams that descend from the southern slopes of the Taurus are necessarily short and rapid. The Sihun and Jihun (the ancient Sarus and Pyramus), which descend the Cilician from the interior highlands, and enter the Gulf of Scanderoon, have, it is supposed, repeatedly changed their lower courses. Of the Syrian rivers the largest is the Orontes, which rises in the Anti-Lebanon, and flows through a narrow valley (the Coele-Syria of Classical Geography), north, past Homs and Hamah, curving at Antakia (Antioch) to the west, entering the sea immediately north of the Jebel-Okrah, the Mount Casius of antiquity.

### Atlantic River-System.—African Section.

<table>
<thead>
<tr>
<th>Name</th>
<th>Length</th>
<th>Area of Basin</th>
<th>Name</th>
<th>Length</th>
<th>Area of Basin</th>
</tr>
</thead>
<tbody>
<tr>
<td>Mulwia</td>
<td>400</td>
<td>(?)</td>
<td>Mejerdah</td>
<td>(?)</td>
<td></td>
</tr>
<tr>
<td>Sheliff</td>
<td>(?)</td>
<td>(?)</td>
<td>Nile</td>
<td>3,000</td>
<td></td>
</tr>
</tbody>
</table>

44. The African Section of the Atlantic river-system comprises the rivers flowing into the Mediterranean, and those that enter the Atlantic directly; in other words, the rivers that drain the northern and western slopes of the African continent. Of the former, the only great river is the Nile. West of the Nilotic delta, numberless winter torrents fall into the sea, but few of them preserve a
continuous flow of water, and even the larger perennial rivers of the Barbary region are unnavigable, and almost dry in summer. Of these the largest are the Mulavia, in Morocco; the Sheliff and Roumel, in Algeria; and the Mejerdah, in Tunis. All these streams rise in the Atlas Mountains, and flow for the most part through deep valleys and narrow defiles.

45. The Nile is not only the longest, but also the most important and interesting of the great rivers of Africa. Both its two great arms, the Blue Nile and the White Nile, issue from freshwater lakes—the former from Lake Dembea, on the Abyssinian plateau; the latter from the vast expanse of the Victoria Nyanga,—the ultimate sources of both branches being the main feeders of these lakes. The White Nile, which must be regarded as the true Nile, leaves the Victoria Nyanga at an elevation of 3,800 feet above the sea, and flows northwest, its descent being marked by the Ripon, Karuma, and Murchison Falls. It then enters the northern end of the Albert Nyanga; leaving which it commences its grand northerly flow—a broad and never-failing stream—to its final outlet in the Mediterranean. Its first great tributary, the Bahr-el-G'hasal, from the imperfectly explored region on the west, is the only considerable affluent which joins the Nile on the left. On the right it is joined first by the Sobat, the Blue Nile, and the Atbara—the last two from the highlands of Abyssinia. From the junction of the Atbara to the sea, a distance of more than 1,200 miles, the Nile does not receive a single tributary. The basin of the middle and lower Nile is hence of exceedingly narrow limits, being, in fact, confined to the immediate course of the stream, and the adjacent tract periodically inundated by its waters.

46. The region over which the annual inundations of the Nile extend is marked by well-defined limits. A chain of high rocks, from eight to nine hundred feet in elevation, accompanies either bank of the river through Nubia and Egypt, only terminating in the latter country at the commencement of the Delta, where the Nile, hitherto a single stream, divides into the Rosetta and Damietta branches. The width of the valley between these bordering chains of rock gradually increases from less than a mile in Nubia, to as much as ten or twelve miles in the middle portion of Egypt. The inundations of the river, and the fertilizing deposit which they leave upon the soil, are strictly limited to this valley, excepting in the broader plain of the Delta, where, from the absence of the bordering hills, they spread over a wider range of country, the surface of which is composed of alluvial deposit from the waters of the great river.

47. The periodical rise of the middle and lower Nile is due to the abundant seasonal rains of Abyssinia, in which the Blue Nile has its origin. The White Nile, originating in an equatorial lake-region, with a rain-fall of ten months duration, constitutes an unfailing and nearly uniform source of supply to the united stream; but the Blue Nile and the Atbara, periodically swelled by an excessive rain-fall of three months, give origin to the floods which annually inundate the Egyptian plain. At Cairo (a short distance above the head of the Delta) the river begins to rise about the end of June, and continues to increase daily until towards the close of September, at which time nearly the whole valley is under water, and the greater part of the Delta is covered with the inundation.
After remaining stationary for a few days, it retires gradually within its proper channel, leaving on the ground which it has covered the feralizing slime or Nile-mud, to which the abundant harvests of Egypt are due. In seasons when, as is occasionally the case, the waters fail to reach their proper height, and consequently do not remain sufficiently long upon the ground, a failure in the harvest is the certain result.

48. The Nile is permanently navigable from its mouths to the cataracts, or rather rapids, in Nubia, which are passed with considerable difficulty, except during the annual inundation. The cataracts and rapids of the White Nile are more formidable, and greatly obstruct the communication by water with the great lakes of Central Africa.

49. Of the rivers that fall into the Atlantic on the western side of Africa, the most considerable are the Senegal, Gambia, Niger, Congo, Coanza, and Orange.

<table>
<thead>
<tr>
<th>ATLANTIC RIVER-SYSTEM.—AFRICAN SECTION.</th>
</tr>
</thead>
<tbody>
<tr>
<td>13.—Flowing directly into the Atlantic.</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Name</th>
<th>Length (Miles)</th>
<th>Area of Basin (Sq. m.)</th>
<th>Name</th>
<th>Length (Miles)</th>
<th>Area of Basin (Sq. m.)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Senegal</td>
<td>900</td>
<td>80,000</td>
<td>Congo</td>
<td>2,900</td>
<td>—</td>
</tr>
<tr>
<td>Gambia</td>
<td>650</td>
<td>30,000</td>
<td>Coanza</td>
<td>—</td>
<td>—</td>
</tr>
<tr>
<td>Niger</td>
<td>2,300</td>
<td>(?)</td>
<td>Orange</td>
<td>1,000</td>
<td>—</td>
</tr>
</tbody>
</table>

50. The Senegal rises under the name of Bafing, in Mount Cooro, not far from the source of the Joliba or Niger. It flows first north, gradually curving west to the sea, which it enters by two mouths, between which is the island of St. Louis. The Gambia rises in the same mountain-group as the Senegal, and enters the sea near Cape St. Mary. The volume of both these rivers varies according to the season. Their upper and middle courses are obstructed by numerous falls, but their lower course is regularly navigated by French and British trading vessels. The Niger rises under the name of Joliba, in Mount Loma, one of the western peaks of the Kong Mountains. It flows north-east through a broad and fertile valley, and becomes navigable at Sego, where it is as wide as the Thames at Westminster. Below this it expands, forming Lake Debu, and at Kabara, the port of Timbuctoo, on the borders of the Great Desert, flows east and south-east under the name of Quorra. The broad and deep Benue, from the mountain-region south of Lake Chad, now joins it; the united stream, a mile in width, then pierces the Kong chain, and enters the plain—dividing, at a distance of about 90 miles from the sea, into numerous channels, the mouths of the most distant of which are 240 miles apart. The delta of the Niger is much larger than that of the Nile, and is nearly everywhere covered with a dense growth of tropical vegetation. The main channel is known as the Nun, and is constantly traversed by steamers to and from the busy trading stations on the river. The position and navigability of the Niger, and its great affluent the Benue, undoubtedly destine them, at no distant date, to play a most important part in the civilization of Western Africa.
51. South of the equator we find, in Cape Lopez, the extreme point of the mangrove-covered delta of the Ogowai, which seventy miles from the sea is a deep and navigable stream, more than a mile wide. The two branches which converge at this point are large rivers, but their navigation is obstructed by rapids and falls. Further south we come to the second great African river, the Congo, or Livingstone River, inferior to the Nile only in length, but discharging into the sea a vastly greater volume of water—perceptible many miles out at sea. This great river rises, under the name of Chambezi, in the Urungu Mountains, south of Lake Tanganyika. The Chambezi flows west into Lake Bangweolo, and issues from it as the Luapula, with a northerly flow into Lake Moero; from which the now considerable stream, under the name of Lualaba, runs north, receiving the Lukuga from Lake Tanganyika, and the overflow of the Kamolondo chain of lakes. Below Nyangwe it falls over a series of cataracts, which terminate in Stanley Falls, near the equator. Thence it curves west and south-west, a broad and navigable stream, until at about 140 miles from the sea it breaks through the Sierra Complida by the Yellala Rapids and Falls. Thence it gradually widens, and enters the sea by a broad estuary, ten miles in width. The banks of the Congo are for the most part fertile and thickly peopled, and the systematic attempts which are now being made to open up this great river to European traffic and civilization seem likely to be crowned with success.

52. The upper course of the Coanza, the chief river of Angola, which has its source in the Mossamba Mountains, not far from those of the Zambesi, is rapid, and broken by rapids and falls, but its lower course is regularly navigated by steamers. On the opposite side of the same range rises the Cunene or Nourse, which is navigable only during the rainy season. The Orange river is formed by the junction of the Vaal and the Nu Gariep, both of which rise on the slopes of Mont aux Sources, one of the loftiest summits of the Drakensberg Mountains. From the junction of its two main branches, the Orange flows west through a narrow valley shut in by precipitous cliffs, receiving no permanent tributary, and constantly decreasing in volume. The Orange, notwithstanding its great length, is a mere torrent, extremely shallow in the dry season, obstructed by formidable cataracts (one of which, Aukurubies Fall, is 150 feet high) and a dangerous bar at its mouth, and consequently unnavigable.

<table>
<thead>
<tr>
<th>Atlantic River-System.—North American Section.</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Name</strong></td>
</tr>
<tr>
<td></td>
</tr>
<tr>
<td>14.—Flowing into Hudson Bay.</td>
</tr>
<tr>
<td>Churchill</td>
</tr>
<tr>
<td>Nelson</td>
</tr>
</tbody>
</table>

53. The **North American** section of the Atlantic river-system embraces not only those rivers which flow into the ocean directly, but also those falling into Hudson Bay and the Mexican Gulf. Of the thirty large rivers which run into Hudson Bay, or its southern extension, James' Bay, the principal are the
Churchill, Nelson, Severn, and Albany. The Churchill, also known as the Missinippi or English River, rises in Lake Methy, and repeatedly expands into considerable lakes, and enters the bay by a single mouth, narrow, but deep—forming, in fact, a splendid natural harbour. The Nelson must be regarded as the main outlet of the great lakes of Winnipeg, &c.—the St. Lawrence of the North-West—and having for its ultimate sources the two great branches of the Saskatchewan. The Hayes river, also an outlet of Lake Winnipeg, discharges its waters into the same inlet as the Nelson. The Severn issues from a lake of the same name—the main feeder of which flows from a small lake, which sends another stream west to Lake Winnipeg. The Albany is the largest of the rivers falling into James' Bay, and some of its tributaries issue from lakes which communicate with Lake Superior. All these rivers have north-westerly courses, through a forest-covered region, and are connected with a perfect labyrinth of lakes and swamps. None of them are navigable for large vessels to any great distance inland, on account of the numerous falls and rapids.

### ATLANTIC RIVER-SYSTEM.—NORTH AMERICAN SECTION.

<table>
<thead>
<tr>
<th>Name</th>
<th>Length (Miles)</th>
<th>Area of Basin (Sq. m)</th>
<th>Name</th>
<th>Length (Miles)</th>
<th>Area of Basin (Sq. m)</th>
</tr>
</thead>
<tbody>
<tr>
<td>St. Lawrence</td>
<td>200</td>
<td>410,000</td>
<td>James</td>
<td>450</td>
<td>10,500</td>
</tr>
<tr>
<td>St. John</td>
<td>400</td>
<td>22,000</td>
<td>Roanoke</td>
<td>350</td>
<td>18,000</td>
</tr>
<tr>
<td>Connecticut</td>
<td>400</td>
<td>11,000</td>
<td>Pedee</td>
<td>350</td>
<td>14,000</td>
</tr>
<tr>
<td>Hudson</td>
<td>325</td>
<td>14,000</td>
<td>Santee</td>
<td>350</td>
<td>16,000</td>
</tr>
<tr>
<td>Delaware</td>
<td>300</td>
<td>12,000</td>
<td>Savannah</td>
<td>400</td>
<td>10,800</td>
</tr>
<tr>
<td>Susquehanna</td>
<td>450</td>
<td>28,500</td>
<td>Altamaha</td>
<td>400</td>
<td>18,000</td>
</tr>
<tr>
<td>Potomac</td>
<td>400</td>
<td>15,000</td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

54. The only great river flowing directly into the Atlantic from the North American continent is the St. Lawrence, which indeed constitutes one of the most important features in the hydrography of the New World, on account of the great chain of lakes with which it is connected, and of which it forms the outlet. These lakes—Superior, Michigan, Huron, Erie, and Ontario—have together an area of more than 90,000 square miles, which exceeds that of the island of Great Britain. The river St. Lawrence, which issues from the lower extremity of Lake Ontario, carries their superfluous waters to the sea, and becomes, in the latter part of its channel, a vast estuary, which gradually increases from twenty-five to a hundred miles in breadth. The great lakes of the St. Lawrence basin indicate a descent in the general level of its waters, which is very gradual until Lake Erie—the lowest but one of their number—is passed. Thence to Lake Ontario the descent is very considerable. The surface of Lake Superior is 596 feet above the level of the sea. Lakes Michigan and Huron are only eighteen feet lower in level, and the surface of Lake Erie corresponds to a further depression of not more than thirteen feet. But between the surface of Lakes Erie and Ontario the difference of level amounts to more than three hundred feet, and the
river Niagara, which connects them, is precipitated midway between the two lakes down the ledge which forms the well-known Falls of that name. From the lower extremity of Lake Ontario to the city of Quebec (where the broader part of its estuary begins), the declivity in the channel of the St. Lawrence is very considerable, amounting to an average of eight inches per mile; and the numerous rocks which occur in its bed give rise to frequent and dangerous rapids. At the city of Montreal, where the Victoria Railway Bridge crosses the St. Lawrence, the river is 6,540 feet (or a mile and a quarter) in width, and flows at the rate of ten miles an hour. During several months of each year it is covered with a coating of ice eight feet thick, and when this breaks up, enormous blocks of ice are carried down the stream with almost resistless force. The Ottawa, which joins the St. Lawrence on its left bank above Montreal, is the most considerable of its tributaries, and exhibits like characteristics. The channels both of the St. Lawrence and the Ottawa open out, at intervals, into broad and lake-like expanses, studded with a multitude of islets, of every variety of form, and covered with a rich luxuriance of vegetable growth.

55. South of the St. Lawrence an undulating and populous plain extends along the Atlantic coast, between the Alleghany Mountains and the sea, which is drained by numerous rivers directly into the Atlantic. Commencing in the north, we have first the river St. John, the chief stream of New Brunswick, entering the Bay of Fundy by a wide estuary; next the Connecticut, the largest river of New England, running into Long Island Sound; the Hudson, a magnificent river, rising in the famous Adirondack Mountains, and becoming navigable for the largest vessels at Hudson, 118 miles from the sea, and having at its mouth the great city of New York; the Delaware, flowing from the Catskill Mountains, sufficiently deep in its lower course to admit seagoing vessels to Philadelphia, and expanding into a long bay; the Susquehanna, Potomac, and James River, all flowing into the magnificent inlet called Chesapeake Bay; the Roanoke, Pee Dee, Santee, Savannah, and Altamaha, rising on the slopes of the Blue Ridge, the easternmost range of the Alleghany system, and draining the states of Carolina and Georgia. The upper courses of nearly all these rivers are rapid, and obstructed by rapids and falls; their lower courses are for the most part unimpeded, and regularly traversed by steamers. Their respective length and drainage area are shown in the above table.

56. Of the rivers flowing into the Gulf of Mexico, the principal are the Apalachicola, and the Mobile or Alabama, both rising on the southern slopes of the Alleghanies, each navigable for three or four hundred miles; the Mississippi, of which a detailed description is appended; the Brazos, Colorado, and other Texan rivers; and lastly, the great frontier river of the Grande del Norte, flowing south-east from the lofty mountains of Colorado, through the wild valleys and uplands of New Mexico, then forming the boundary between Mexico and Texas. Of its numerous tributaries the largest is the Pecos, which rises in the Moro Range. The Rio Grande is navigable to the great rapids, 450 miles from the sea. But by far the most important river in North America is the Mississippi, which, with the single exception of the Amazon, surpasses every other river on the globe, both in length of channel and area of drainage.
57. The *Mississippi*, "father of waters"—such is the meaning of the name—rises in Lake Itasca, within the heart of the great American plain, and has a southward course of 2,400 miles to the Gulf of Mexico. Midway on this course, it receives on its right bank the longer stream of the *Missouri*, which comes from the Rocky Mountains, and flows 2,500 miles (in the general direction of south-east) ere it joins the Mississippi. Measuring from the mouth of the Mississippi upward to the point of junction, and thence by the Missouri to the source of the latter, the whole length of river-channel is upwards of 4,000 miles. The navigation of the Mississippi proper exceeds 2,000 miles in length, and by the Missouri arm is more than 3,900 miles. The breadth of the river nowhere exceeds three-quarters of a mile, and is seldom more than half a mile, even in the lower portion of its channel, excepting during periods of annual flood, when the waters cover a vast extent of the adjoining plain. The spread of the inundation is, however, limited by a range of high "bluffs" which bound the alluvial plain upon either side, at varying distances from the proper channel of the stream. Below the junction of the Ohio, this plain is from thirty to fifty miles across. In general, the river flows much nearer the base of the eastern bluffs than to those of the western side of the plain. The vast flood of water which the Mississippi and Missouri, with their numerous tributaries, bring down to the sea, occasions frequent and considerable changes in the depth and other conditions of their channels. The water acts with destructive force upon the soft alluvial soil, wearing away the banks, and depositing the material in the bed of the stream. The extensive banks, and even islands, which are thus formed undergo frequent changes, every successive season producing alterations in the river's bed. The most important among the numerous tributaries of the Mississippi, next to the Missouri, is the Ohio, which comes from the Alleghany Mountains, and joins the left bank of the main stream, 200 miles below the junction of the Missouri. The *Ohio* has a course of 950 miles above the junction, and is highly important as a channel of navigation. The whole area of the Mississippi basin is more than a million and a quarter of square miles.
### Atlantic River-System.—South American Section.

#### 17. Flowing into the Caribbean Sea.

<table>
<thead>
<tr>
<th>Name</th>
<th>Length</th>
<th>Area of Basin</th>
</tr>
</thead>
<tbody>
<tr>
<td>Atrato</td>
<td>300</td>
<td>11,000</td>
</tr>
<tr>
<td>Magdalena</td>
<td>860</td>
<td>98,000</td>
</tr>
</tbody>
</table>

#### 18. Flowing directly into the Atlantic.

<table>
<thead>
<tr>
<th>Name</th>
<th>Length</th>
<th>Area of Basin</th>
</tr>
</thead>
<tbody>
<tr>
<td>Orinoco</td>
<td>1,200</td>
<td>400,000</td>
</tr>
<tr>
<td>Essequibo</td>
<td>600</td>
<td>84,000</td>
</tr>
<tr>
<td>Demerara</td>
<td>200</td>
<td>3,500</td>
</tr>
<tr>
<td>Berbice</td>
<td>360</td>
<td>7,000</td>
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<tr>
<td>Corentyn</td>
<td>470</td>
<td>20,000</td>
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<tr>
<td>Surinam</td>
<td>350</td>
<td>12,000</td>
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<tr>
<td>Maroni</td>
<td>400</td>
<td>18,000</td>
</tr>
<tr>
<td>Amazon</td>
<td>3,900</td>
<td>2,500,000</td>
</tr>
<tr>
<td>Maranhao</td>
<td>360</td>
<td>—</td>
</tr>
<tr>
<td>Parahyba</td>
<td>750</td>
<td>—</td>
</tr>
<tr>
<td>San Francisco</td>
<td>1,500</td>
<td>254,000</td>
</tr>
<tr>
<td>Grande Belmorte</td>
<td>500</td>
<td>—</td>
</tr>
<tr>
<td>Parahyba</td>
<td>—</td>
<td>—</td>
</tr>
<tr>
<td>La Plata</td>
<td>350</td>
<td>1,240,000</td>
</tr>
<tr>
<td>Parana</td>
<td>—</td>
<td>—</td>
</tr>
<tr>
<td>Uruguay</td>
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</tr>
<tr>
<td>Colorado</td>
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</tr>
<tr>
<td>Negro</td>
<td>800</td>
<td>—</td>
</tr>
<tr>
<td>Chupat</td>
<td>—</td>
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<tr>
<td>Santa Cruz</td>
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58. The **South American Section** of the Atlantic river-system surpasses all the other sections in the number, magnitude, and navigability of its component rivers. This results from the close proximity of the Andes to the Pacific coast, so that nearly the whole of the continent has its slope directed towards the Atlantic. Three of the South American rivers greatly exceed the rest in magnitude and geographical importance,—namely, the Amazon, La Plata, and Orinoco. The Amazon alone, the largest river in the world, drains an area equal to more than a third of the continent, and the three together water nearly three-fifths of its total extent. Of the smaller rivers the principal are the Atrato and Magdalena, north-west of the Orinoco; the Essequibo, Demerara, Berbice, Corentyn, Surinam, and Maroni, between the Orinoco and Amazon; the Maranhao, Parahyba, San Francisco, Grande do Belmonte, and Parahyba, between the Amazon and the La Plata; and the Colorado, Negro, Chupat, and Santa Cruz, south of the La Plata.

59. The **Atrato** waters the rugged valley between the two western cordilleras of the Colombian Andes, and flows north into the Gulf of Darien. The **Magdalena**, and its chief tributary, the Caucá, drains the valleys that intervene between the three principal chains of the Andes—the most easterly of which divides its basin from that of the Orinoco. This great river rises in the western defiles of the Parime Mountains, and flows first west, then curves north and east, describing nearly a semicircle, and ultimately forming a delta of vast extent, intersected by numerous channels. The Orinoco is joined by a great number of tributaries, of which the Guaviari, Meta, and Apure flow from the Andes, and the Caroni and Caura from the Parime Mountains. The navigation of this noble stream is occasionally interrupted by rapids, none of which, however, are very formidable, and most of its tributaries are also navigable. About 130 miles from its source the Orinoco throws off from the main channel a branch
which joins the Rio Negro, an affluent of the Amazon. This branch, which bears the name of Casiquiare, has a length of nearly 200 miles before it joins the Negro. Two great river-basins are thus united by a natural channel, so that a boat might pass from the mouth of the Orinoco into the Negro, thence into the Amazon, and down the latter stream to its outlet—thus making the circuit of a large portion of the South American continent, and passing round the extensive region of the Guinea mountain-system. There is no other instance in the world of the permanent bifurcation of a stream of such magnitude, though a few similar examples occur elsewhere among streams on a smaller scale.

60. Of the rivers that enter the sea between the mouths of the Orinoco and Amazon, the Essequibo, Demerara, and Berbice drain British Guiana; the Corentyne forms the boundary between Dutch and British Guiana; the Surinam runs through the centre of Dutch Guiana; while the Maroni flows between Dutch and French Guiana. The whole region drained by these rivers presents a terraciform aspect, rising step by step from the coast to the distant ranges in the interior. The upper courses, therefore, of all these rivers are broken by falls and rapids, which mark the descent from each terrace; their lower courses are navigable by moderate-sized vessels.

61. The great river Amazon, the "Mediterranean of South America," drains a much larger area, and affords a greater extent of inland navigation than any other river in the world. The Maranon, which rises in the small lake of Lauricocha, on the high tableland of Pasco, at an elevation of more than 14,000 feet, is generally regarded as the main stream of the Amazon, though the Ucayali and other tributaries, which come from a more southern source, are of greater length. Upon issuing from Lake Lauricocha, the Maranon flows rapidly north between the two main cordilleras of the Andes, descending about 10,000 feet in little more than 100 miles, bending at Jaen to the north-east, and, breaking through the mountains by the long defile of Pongo de Manseriche, enters the great plain as a first-class river, upwards of 2,500 feet wide, freely navigable for large vessels. Flowing now east, it is joined by several large tributaries on the left, and on the right by the considerably larger streams of the Huallaga and the Ucayali—the latter of which is regarded by some geographers as the true Amazon, it being superior both in length and volume to the Maranon. It then receives successively, on the left, the Napo, Putumayo, Yapura, and Negro, and on the right, the Javari, Purus, Madera, Tapajos, Xingu, and Tocantins. All these are streams of the first magnitude, the Madera having a course of 2,000 miles, and the Negro of 1,400 miles. The remarkable connection of the latter with the Orinoco by the Casiquiare has been already noticed. It is also worthy of note that a narrow portage of three miles, consisting of grassy plain, alone divides the Aguapehy, one of the small tributaries of the Upper Paraguay, from a similar affluent of the Guapore river, one of the main sources of the Madera. The basins of the Amazon and the La Plata are thus capable of easy union with one another, and, when the Savannahs are temporarily laid under water by the rains, the canoes of the Indians actually pass from the one to the other. The breadth of the Amazon increases from one mile at its confluence with the Napo, to three miles at Barra do Rio Negro, to upwards of four miles below Obydos;
and the great river finally enters the sea by an estuary below the island of Caviana, fifty miles wide at its mouth. But the most frequented channel of entrance to the Amazon is formed by the Rio do Para and the Tananpa Channel, which encircle the large island of Marajo. The extent of inland water-communication afforded by the Amazon and its numerous tributaries is unparalleled—on the main stream there is not a single insurmountable obstruction from the sea to the rapids of Reutema, near Jaen, a direct distance of more than 2,000 miles. Nearly all its great tributaries are also navigable for several hundred miles. The Madera is obstructed by numerous falls, which will probably be avoided by lateral canals. The enormous volume of water discharged by this great river forms an easterly current, perceptible 200 miles from the coast, while the tides are felt in the main stream as far as Obydos, 400 miles from the sea, and even in the smaller affluents of its great tributaries at distances of above 500 miles inland. The dangerous "bore" which occurs at spring tides has been already noticed.

62. The region east of the Tocantins, the last great tributary of the Amazon, is drained by numerous streams which fall directly into the ocean. The Maranhao and Paranhyba, both navigable streams of considerable magnitude, flow through a low swampy district; the much longer San Francisco, a magnificent stream, equal in length to the Danube, waters the long valley between the coast range and the interior sierras. Its general course is north-east as far as San Maria, where it bends to the east. This fine stream is unfortunately impeded by numerous falls; those of Paulo Affonso, 168 miles from the sea, mark the limit of its free navigation by sea-going vessels. The narrow plain between the coast range and the sea south of the lower San Francisco, is watered by numerous streams, among which are the Paraguassu, Grande do Belmonte, and Parahyba; the last is navigable for 60 miles inland. The Rio de la Plata is an immense estuary, formed by the junction of the Parana and Uruguay. The Parana, the main stream, rises under the name of Rio Negro on the western slopes of the Sierra Montiguiera. Its course is interrupted by numerous falls, the most remarkable of which are the Salto Grande. At Corrientes it is joined by the Paraguay, which rises in the sterile upland known as the 'Campos de Parecis,' and receives from the Andes several large tributary streams, such as the Pilcomayo and Vermeno. During the rainy season the Paraguay inundates the adjoining plains to a depth of 10 or 12 feet. Below Corrientes the Parana flows south, receiving, near Santa Fé, the Salado from the plateau of El Despoblado; bending at Rosario south-east, uniting with the Uruguay a few miles north-west of Buenos Ayres, to form the extensive but shallow estuary of the La Plata. The Uruguay rises in the Sierra Catharina, and flows for the most part parallel to the Parana. From its source to within 200 miles of its mouth its navigation is repeatedly interrupted by cataracts. The immense volume of water discharged by the Parana and Uruguay, through their common outlet, the Rio de la Plata, forms a perceptible fresh-water current at a distance of 100 miles from the coast. The southern portion of the Pampas is drained into the sea by two long rivers, the Colorado and the Negro, the latter of which forms the northern boundary of Patagonia. The sterile, treeless plains of Patagonia, are seamed by few considerable water-courses—the Chupat, Desire, and Santa Cruz being the largest.
63. The **Pacific River-system** is inferior to that of the Atlantic, both in the number and average length of its streams. The area of the Pacific Ocean is nearly twice that of the Atlantic, but, owing to the proximity and continuity of the high grounds which encompass the Pacific, especially on its eastern or American side, its drainage area is \( \frac{2}{3} \) times less—being estimated at 8,460,000 square miles, while the area drained into the Atlantic amounts to 19,050,000 square miles.

<table>
<thead>
<tr>
<th><strong>Pacific River-System.—American Section.</strong></th>
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<tr>
<td><strong>I.—Flowing into the Pacific Ocean.</strong></td>
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<tr>
<td><strong>NAME.</strong></td>
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<tr>
<td>Yukon</td>
</tr>
<tr>
<td>Fraser</td>
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<td>Columbia</td>
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<td>Sacramento</td>
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64. The **American Section** of the Pacific river-system is remarkable for the paucity of any great streams. In South America the Andean mountain-wall skirts the Pacific coast in unbroken continuity from Cape Froward to Panama, at a distance nowhere more than eighty miles inland. There is therefore no room for the development of any considerable streams—two only attaining a length of over 150 miles. In Central America, the same proximity of high ground to the coast, and consequent absence of large rivers, is seen. In North America a series of lofty ranges skirt the coast closely, but it is repeatedly broken through by several large streams which flow from the main axis of elevation—the Rocky Mountains. In the extreme north-west the continent juts out, forming the great peninsula of Alaska, while the direction of the main mountain-chain is unchanged; here, therefore, the larger area admits of the formation of a magnificent stream, the *Yukon*, the longest river of Western America. This river is formed by the confluence of the Pelly and the Lewis; the former flowing from the Rocky Mountains, and the latter from the coast range. Flowing north-west it is joined at Fort Yukon by the Porcupine; thence it runs in a westerly direction, entering the Sea of Behring by several mouths. This great river is free from ice only for four months in the year; it is then navigable for a distance of 180 miles from the sea. The *Fraser* is chiefly famous for the rich gold-fields in the upper portion of its valley; issuing from Moose Lake, in the Yellow Head Pass, it flows north-west, then south, and finally west—its course being a succession of lakes, waterfalls, and rapids. In spite of the rapidity of its current, powerful steamers ascend for nearly 200 miles from its mouth. The *Columbia* or Oregon rises in a small lake in the Rocky Mountains, near Mount Sabine. Its course is extremely tortuous; below its junction with the Snake River, it turns west, and enters the sea at Astoria. The *Sacramento*, with its
great tributary, the San Joaquin, waters the auriferous valley between the Sierra Nevada and the coast range; it falls into the magnificent bay of San Francisco. It is navigable for large vessels for 50 miles from the sea. The Colorado has for its head stream the Green River, which rises in the Rocky Mountains near Fremont's Peak. Its general course is south-west, flowing for the most part through a succession of deep gorges—one of which, the Grand Cañon, is 300 miles long. Further south a few insignificant streams descend from the highlands of Mexico and Central America. Of the numerous short and rapid streams which drain the narrow plain west of the Andes, the largest is the Biobío, in Chili, which is navigated by small vessels as far as Nacimiento. Although of small length, its volume is considerable, and its width near its mouth is two miles.

65. The Asiatic Section of the Pacific system is the most important, both in the number and magnitude of its rivers, which rise far inland, among the mountains that buttress the great central plateau of Asia. The principal streams are the Amur, forming for the most part the boundary between the Russian and Chinese dominions—the Hoang-ho, Yang-tsze-kiang, Chu-kiang, in China—the Sang-koï, Mekon, and Menam, in Further India.

66. The Amur is formed by the confluence of two streams, the Chilka and the Argun, both of which rise in the mountains south-east of Lake Baïkal. Below their junction the now considerable river breaks through the Khinghan chain, and flows eastwards, receiving the Deêya, and other smaller affluents from the Yablonoi mountains on the north, and on the south the Sungari (the great river of Manchuria) and the Usuri. After its junction with the latter stream, the Amur bends north, and enters the sea about twenty miles below Nikolaevsck. This fine river is navigable by light steamers to within 300 miles of its source, but it is frozen over from November to June. Both the great rivers of China, the Hoang-ho and the Yang-tsze-kiang, issue from the mountain-regions of Eastern Tibet; within China their basins are separated by the latitudinal chain of the Pe-ling Mountains. The upper Hoang-ho is extremely winding—flowing first south-east, then bending north-east to the Inshan Mountains, along the base of which it runs east for about 100 miles. It then turns due south, cutting for the fourth time through the "Great Wall,"—that useless monument of Chinese industry. Being joined by the Wei-ho, it again turns east, and near Kai-fung turns north-east, and enters the Gulf of Pe-che-lee. Before the year 1854 the Hoang-ho entered the Yellow Sea about 100 miles north of the mouth of the Yang-tsze-kiang. In that year, however, it burst through the artificially-formed mounds which the continued deposit of ages had rendered necessary for the confinement of its channel, and it now flows in the former bed of the Ta-tsing-ho—its present mouth being thus 300 miles north of its former embouchure. Off the latter—now dry—its sands stretch seaward for upwards of a hundred miles, rendering it dangerous for large ships to approach that portion of the coast. In the course of this disastrous change, it has destroyed a large portion of the Imperial Canal—the great highway for the conveyance of grain to the Chinese metropolis. According to native accounts, this river has changed its lower course no less than nine times during the last 2,500 years. It is of little value for navigation; its current is rapid; it is also shallow, and subject to
sudden changes in depth. Vastly more important to the teeming millions of China is the Yang-tze-kiang, which, leaving the mountains by a deep gorge, turns east, watering the fertile and densely-peopled alluvial plain between the Pe-ling on the north and the Nan-ling on the south, from both of which it receives many large affluents. At Hankow, 700 miles from the sea, it is fully a mile wide, while above Nankin its normal width is four miles, expanding in flood to twenty miles. Large steamers easily ascend this noble stream to I-chang, 1,200 miles from the sea; boats and smaller steamers force their way 600 miles higher. The vast quantity of sediment which it brings down causes frequent changes to take place in the islands and banks that occur in its bed, and the sea adjacent to its estuary is being gradually silted up. The Hoang-ho also carries down an immense amount of mud, which will in time fill up the already shallow Gulf of Pe-che-lee. The third great river of China is the Chu-kiang, or Si-kiang; between its basin and that of the Yang-tze-kiang are the Nan-ling Mountains. This river enters the China Sea by a wide estuary (known as the Boca Tigris) studded with islands and rocky islets. It is an important commercial highway, being ascended by the largest vessels to the great port of Canton, and by smaller craft for upwards of 300 miles inland. Only two of the great rivers of the Indo-Chinese Peninsula belong to the Pacific basin—viz., the Mekon and the Menam. The Mekon rises in the highlands of Yunnan, not far from the banks of the Yang-tze-kiang, and flows south-east, traversing Eastern Burmah, the great alluvial plain of Eastern Siam, and Cambodia, entering the sea by numerous mouths, which form an extensive delta. The better-known stream of the Menam flows from the southern frontiers of Burmah, first through the hill country of the semi-independent Laotians, and then through the great valley of Siam, entering the head of the Gulf of Siam by three mouths, about 20 miles below the busy port of Bangkok. Both the Menam and Mekon, like the Nile, overflow their banks, and thus fertilize the country through which they flow.

67. The Australian Section of the Pacific river-system presents the same characteristic features as the South American—in both a continuous cordillera limits the area for river development to a narrow tract between the mountains and the sea. The Australian Alps and its northerly continuation, of course, are insignificant compared with the vast chain of the Andes—still, the streams that enter the Pacific from the latter are shorter and less navigable than those which descend from the former.

68. Of the coast streams of Queensland, the principal are the Burdekin, Fitzroy (formed by the junction of the Mackenzie and Dawson, with their subsidiary creeks), Burnett, and Brisbane, all of which are navigable for steamers of considerable tonnage for some distance inland. In New South Wales the coast-plain is watered by many noble streams, the largest of which are the Clarence, MacLeay, Manning, Hunter, Hawkesbury, and Shoalhaven. The volume of all these rivers varies greatly, being in winter liable to sudden and violent floods. But they are not altogether worthless. The Clarence is half a mile wide at its mouth, and is navigable for sea-going steamers for 70 miles; the Hunter and other rivers are also regularly traversed by colonial trading vessels. In Victoria, the Snowy River, Mitchell, and other smaller streams fall into the Pacific; the
other rivers of the colony, and indeed of the whole continent, with the exception of those already named, belong to the basin of the Indian Ocean.

69. The River-system of the Indian Ocean.—Bounded as the Indian Ocean is, on three sides, by Australia, Asia, and Africa, its river-system is naturally divisible into three sections—the Australian, Asiatic, and African.

70. The Australian Section of the system comprises the Murray, which enters Encounter Bay through Lake Alexandrina; the Swan, Murchison, Gascoyne, Ashburton, and other rivers of Western Australia; the Victoria and Daly, which enter Cambridge Gulf; and the Roper, Flinders, and Mitchell, which fall into the Gulf of Carpentaria.

71. The Murray rises on the western slopes of the Australian Alps, about 15 miles south of Mount Koskiusko, and becomes navigable at Albury, about 150 miles from its source. Throughout its upper and middle course the Murray forms the boundary between the Colonies of Victoria and New South Wales; its lower course, below its junction with the Darling, is within South Australia. From Victoria the Murray receives the Mitta Mitta, Ovens, Goulburn, Campaspe and Loddon, the valleys of some of which are highly auriferous. On the north the two great tributaries, the Murrumbidgee and Darling, with their subsidiary creeks, drain the whole of New South Wales, and a part of Queensland west of the Great Dividing Range. The Murrumbidgee rises near the Murray in the Muniong Range, and is joined, about 50 miles above its junction with the Murray, by the river Lachlan. The Darling is formed by numerous periodical streams, of which the largest are the Macquarie and Condamine. The average width of the Murray is about 240 feet; depth, 16 feet; but it undergoes great variation according to the season of drought or rain. The Murray is regularly navigated, at certain seasons of the year, to Albury, 1,000 miles above its mouth; small steamers also ascend the Murrumbidgee for 500 miles, and the Darling as far as Bourke, a distance of 600 miles. The Murray and Murrumbidgee alone are perennial streams, the rest are, for the most part, mere surface torrents supplied by the rains, and consequently liable to sudden and violent floods. During seasons of drought they become speedily dried up under the intense heat of an Australian sun, or the stream is converted into a chain of pools. With the recurrence of the rainy season vast floods of water are poured through their beds, and huge trunks of trees, masses of rock, and other debris, swept down by the stream, bear witness to the violence of the torrent.

72. Of the numerous streams of Western Australia, the Swan only is navigable to any extent. In the northern territory, the Victoria has long since been proved to be navigable for a considerable distance; while the Roper, which flows into the Gulf of Carpentaria, is now known to be a magnificent stream, easily ascended by large steamers and sea-going vessels for 100 miles from its mouth. The Flinders and the Mitchell are the largest of the many streams that converge into the south-eastern portion of the Gulf of Carpentaria. The fine country through which they flow is gradually being occupied and utilised for both pastoral and agricultural purposes.
73. The Asiatic Section of the system comprises some of the largest rivers of the globe, such as the Irawadi, Brahmaputra, and Ganges, which fall into the Bay of Bengal; the Indus, flowing into the Arabian Sea; and the Tigris and Euphrates, which unite their waters before debouching into the Persian Gulf. Of the smaller streams comprised in this section, the principal are the Saluen and Sitang, flowing into the Gulf of Martaban; the Mahanuddy, Godavery, Krishna, and Cauvery, draining the eastern slope of Peninsular India; and the Taptty and Nerbudda, flowing into the Gulf of Cambay. Between the Indus and the Shat-el-Arab, a few unimportant rivers enter the sea, but the whole circuit of the Arabian coast is unbroken by the outlet of any permanent stream.

74. Both the Saluen and Irawadi rise in the mountains of Yunnan, and flow almost due south to the sea. The Saluen is navigable for a considerable distance inland, but it is not so well known as the Irawadi, which is regularly traversed by British steamers as far as Bamo, 900 miles from the sea. Below Ava the general width of the stream is from one to four miles; 70 miles from the sea the stream divides, ultimately discharging its waters by fourteen mouths. The enclosed delta is much more extensive than that of the Nile, and is covered with low jungle, noble forests, or productive rice-fields.

75. The Brahmaputra, the most easterly of the three great rivers which derive their chief supplies from the Himalayas, is said to rise, under the name of Sampo, in the vast glaciers which cover so large a portion of the elevated region, whence also issues the Indus, Sutlej, and Ganges, each of which flows west. But the Sampo has an eastwardly course for several hundred miles, then turning suddenly south, breaks through the mountains, and emerges on the plain under the name of Dihong. Being joined by a large river which, until the discovery of the Sampo, was considered the main stream, it flows west through Assam, then curving south, through the plains of Bengal, effects a junction with the eastern outlet of the Ganges. The Brahmaputra, notwithstanding its somewhat rapid current and occasional obstructions, is generally navigable both in Tibet and India. In Assam its channel is studded with islands, and bordered by numerous ana-branches; in Bengal it is a magnificent stream, four or five miles in width, and with a larger volume than any other river of Southern Asia. The whole of the valley of the Brahmaputra south of the Himalayas is periodically inundated; the river rising frequently to a height of 30 to 40 feet above its normal level. It is worthy of remark that the Brahmaputra and Ganges rise near each other, flow at first in opposite directions until they are 1,200 miles apart, then suddenly change their courses, rapidly approximating each other, at length uniting their waters in a common channel at a point about 40 miles from the sea. But the Brahmaputra, notwithstanding its superior length and volume, is far less important than the Ganges, the work done by which "as the water-carrier and fertilizer of the densely populated provinces of Northern India, from its source in the Himalayas to its mouth in the Bay of Bengal, entitles it to rank as the foremost river on the surface of the globe, and fully excuses the affectionate reverence and divine honours paid to it by the Hindus. A great river like the Ganges has three distinct stages in its life from its source to the sea. In the first stage it dashes down the mountain sides, cutting out for itself deep gullies
in the solid rock, and ploughing up glens and ravines on its way. The second stage is where it emerges from the mountains on to the plain, running then more peaceably along the valleys, and seeking out for itself the lowest levels. Here it receives the mud and drainage of the country round, absorbs tributaries, and rolls forward with an ever-increasing volume of water and silt. Finding its speed checked by the equal level of the plains, and its bed raised by its own silt, it splits out into channels, like a jet of water suddenly obstructed by the finger, or a jar of liquid suddenly dashed upon the floor. Each of the channels thus formed throws out in turn its own channels to right and left. In the case of the Ganges, the country which these many offshoots enclose forms the delta of Bengal." Retracing briefly the course of this great river, we find that, after winding through the rugged mountain-region, it breaks through the last of the sub-Himalayan ranges, the Siwalik Hills, and enters the plain at Hurdwar, and flows south-east parallel to its first great affluent, the Jumna, which, rising in the Himalayas, receives important accessions from the Aravalli and Vindhya Mountains, and joins the main stream at Allahabad. The united stream then winds in an easterly direction, receiving from the south the Sone, and from the Himalayas, on the north, the Goomtee, Gogra, Gunduck, and Coosy. Below its junction with the Coosy, the Ganges turns south, and at a distance of 220 miles from the sea, divides into two great arms—the main branch retaining the name of Ganges, and bending south-east to its junction with the Brahmaputra; the western branch, known as the Hooghly, though inferior in width and volume, is commercially more important, and forms the ordinary channel of entrance. The triangular tract enclosed between these two branches is intersected by a labyrinth of channels, "so various in point of width, that a vessel has at one time her masts almost entangled in the trees, and at another sails uninterrupted on a capacious river." The upper portion of the Gangetic delta is fertile and well cultivated; the lower part forms the pestilential "Sunderbunds," covered with jungle, and infested by tigers. In spite of unfailing sources of supply, evaporation is so active in the great plain, that the volume of the river perceptibly decreases as it approaches the sea, except during the floods, when it overflows its banks and inundates the adjoining plain. When in flood it also frequently changes its channel; for instance, Rajmahal, formerly on the banks of the river, is now more than seven miles distant. Large sea-going vessels ascend the Hooghly as far as Chandernagore, a few miles north of Calcutta—the main stream is navigable by small steamers to Cawnpore, and thence by canal to Hurdwar, 1,300 miles from the sea. Some of its great tributaries are also navigable—the Jumna and connected canals afford a practicable waterway for vessels of light draught for 200 miles above Delhi. Both the Brahmaputra and Ganges bring down a vast amount of sediment, which not only adds to their delta, but is gradually silting up the head of the Bay of Bengal.

76. The Brahmaputra and Ganges derive their waters not only from the snows of the Himalayas, but also from the monsoon rains. The numerous streams that drain the Deccan, on the contrary, are supplied entirely by the monsoon rains, and are thus subject to comparatively greater variations in depth and volume. The line of elevations that mark the edge of the Deccan being continuous on the western side only, (the Eastern Ghauts being merely a series of
detached elevations,) all the great rivers of Peninsular India, with the exception of the Nerbudda and Tapty, flow eastwards into the Bay of Bengal, their descent from the plateau to the coast plain being marked by rapids or falls. The Mahanuddy, though notorious for its destructive floods, is yet navigable by boats for nearly 400 miles. Rising in the Mekal Hills, it drains a wild and rugged district, descending into the plain by a gorge 40 miles long, and entering the sea by several mouths, which enclose a great delta, extending from Point Palmyras to the Chilka Lagoon. But the river of the Deccan is the Godavery, whose source in the Western Ghauts, not 50 miles from the shores of the Arabian Sea, is the crowded resort of pilgrims from all parts of India. Flowing east, it receives at Seroncha a considerable affluent from the Satpura Mountains, then bending south, it forces the passage of the Eastern Ghauts by a wild gorge, 20 miles long, and enters the sea by two principal channels. The obstructions which formerly impeded the navigation of this river have been removed, so that it is now regularly traversed by light steamers. The adjacent stream of the Krishna rises, like the Godavery, on the eastern side of the Western Ghauts; but the rapidity of its channel, and the height of its banks, render it almost entirely unnavigable and useless for irrigation, except near the coast, where its delta is watered by means of embankments thrown across its channel. The low tract between the deltas of the Krishna and Godavery is annually inundated, and the intervening Lake Colair is permanently connected with the Krishna. South of the Krishna, the North Pennar, Palar, and South Pennar rise in the hills of Mysore, and water the northern portion of the Carnatic. The last great river of Peninsular India is the Cauvery, the descent of which, from the plateau to the plain, is marked by two magnificent falls, one 370 feet, and the other 460 feet, in height. Below Trichinopoly it divides into numerous branches, some of which are adapted both for irrigation and navigation. On the western side of India the only large rivers are the Tapty, Nerbudda, and Indus. The Tapty rises in the Satpura Mountains, and flows west through the valley formed by them and the edge of the adjoining table-land. The Nerbudda, which has a much longer course, rises in the Mekal Hills, near the source of the Mahanuddy, and flows through a narrow valley, between the Vindhya and Satpura Mountains. A rocky bed and rapid fall renders both these streams all but unnavigable, and they are, besides, subject to sudden and destructive floods. The Indus, the great river of Western India, like the Ganges and Brahmaputra, also rises in the Himalayas, but at a much greater elevation. It flows at first north-east, through a rugged valley bounded by the Karakorum and the Himalaya. At its confluence with the Yasun it turns south-west, and breaks through the mountains into the great plain. At Attock it receives the Cabul river, and becomes navigable; about 400 miles further south it receives, in one stream, the collected waters of the five rivers—Jelum, Chenab, Ravee, Beas, and Sutlej—which confer on the district through which they flow the appropriate name of Punjaub, that is, the country of the five rivers. Thence to the sea it receives a few minor tributaries from the Soliman and Hala Mountains on the west, and finally discharges its waters by numerous mouths. It carries to the sea four times as much water as the Ganges, but its arid and thinly-peopled valley contrasts strongly with the populous and fertile valley of the latter river.
It begins to rise in March, and attains its greatest height in August, but its inundations are usually limited to a mere strip along its banks. Occasionally, however, a sudden débâcle has inundated its entire valley. That of 1841, caused by an ice-barrier in the Khundan Valley, is noticed in Chapter XI. The difficulty of navigating the Indus and its tributaries is of less moment since the opening of the railway from Kurrachee to Lahore and Peshawur. The only other large rivers of the Asiatic section of the system are the Euphrates and Tigris, which discharge their waters by a single stream, the Shat-el-Arab, which has a course of about 130 miles into the Persian Gulf. The Euphrates is formed by the junction of two streams, both of which rise in the Armenian highlands, and descends to the great plain by a succession of falls and rapids. The numerous dams thrown across the river in the upper portion of the plain, for irrigation, greatly obstruct its navigation, so that it is now, to a great extent, impassable by ordinary steam power. Properly embanked and canalized, this noble stream would, undoubtedly, become an important part of a great highway between Europe and India. The adjacent stream of the Tigris rises in the Mountains of Kurdistan, and, like the Euphrates, flows south-east. North of Bagdad the two great rivers enclose a magnificent plain, the ancient Mesopotamia; south of that town they flow through the equally famous plain of Irak-Arabi, the ancient Babylonia.

77. The African Section of the system is vastly inferior to the Asiatic, both in the number and magnitude of its rivers. Although the eastern edge of the great African plateau does not approach the coast as closely as the western, still the interior drainage north of Lake Nyassa flows north into the Nile, or west into the Congo, so that the rivers flowing into the Indian Ocean have comparatively short courses. The most considerable in point of length appear to be the Raffles River, the outlet of which is barred by sand-hills, and the longer Juba, which probably rises on the southern borders of the Abyssinian highlands; the last 180 miles of its course were navigated by the unfortunate Baron Von der Decken in 1865. South of the equator, the Kingani and Wami, which enter the channel between the island of Zanzibar and the mainland, have been recently proved to be practically useless for navigation. The lower 40 miles of the Wami, however, might be made fairly navigable. The Rufiji River was explored in January, 1881, by Mr. Beardall, under the orders of the Sultan of Zanzibar. He found that the river varies in breadth from 100 to 450 yards, and that, owing to numerous shallows and sandbanks, it will never be of much use for navigation, except by native canoes, and small flat-bottomed boats. The Rovuma, which enters the sea by a single channel about 16 miles north of Cape Delgado, has also been explored by order of the Sultan, in order to ascertain whether the coal-beds reported to exist on the banks of the Lujende, one of its southern tributaries, were accessible by water. The Zambesi, the largest river of Eastern Africa, rises under the name of Leeba in Lake Dilolo, and about 200 miles from its source receives the Leambye, from the Mushonga Mountains, which form part of the watershed between the basins of the Congo and the

1 In August, 1881, Mr. Thomson found that the supposed coal-beds were only a few layers of bituminous shale.
Zambesi. It then turns south-east through the Barotse valley; its course between the 16th parallel of latitude and the Victoria Falls, a distance of 220 miles, being, according to Major Serpa Pinto, obstructed by no less than seventy-two cataracts and rapids. About 40 miles above the Falls, the Chobe, or Cuando, joins the main stream on the right bank. Below the Falls the Zambesi flows with a rapid current eastwards, receiving several large tributaries both from the south and north. At Tete, where it becomes navigable, it bends south-east, and discharges its waters by several mouths. Its delta, which is larger than that of the Nile, is periodically inundated. About 100 miles from the sea, the Zambesi is joined by the Shire, which drains Lake Nyassa. The navigation of the Shire is unfortunately obstructed by the Murchison Cataracts. The only other large river of Eastern Africa is the Limpopo, which derives its head-waters from the Witwater Rand, and other ridges on the "Hooge Veldt" of the Transvaal. Its course, north-east, east, and south-east, forms almost a semicircle; its mouth (40 miles north of Delagoa Bay) being only about one degree north, and scarcely 400 miles east of its source, while the total length of the stream is estimated at 1,300 miles. Mauch, who crossed this river twice between 31° and 32° of longitude, observes:—"The nearer I came to this river, the more I was disappointed respecting its qualities. Instead of a broad, navigable, and deep river, passable with the greatest difficulty, I perceived a tremendous sand-river, 1,250 yards broad, of which about 150 yards of the southern bank were covered with knee-deep, rapid-running water. The rest is covered with deep, coarse sand, or sparsely-growing reed-grass." The late Captain Elton, who explored the river in 1870, was of opinion that it could be navigated by light steamers for a distance of 336 miles from the sea. Of the many streams which flow from the Drakensberg to the sea, the longest is the Tugela, the lower course of which forms the boundary between the colony of Natal and Zululand.

**Continental River-Systems.**

78. Besides the oceanic-drainage systems we have described, there are also extensive regions of inland-drainage—that is, large areas watered by rivers which have no outlet to the sea. In the Old World the region of inland-drainage includes a large portion of the Asiatic and European continents, extending from within less than 200 miles of the Baltic Sea on one side to the borders of China and Manchooria on the other, through nearly ninety degrees of longitude. The Caspian Sea and the Sea of Aral receive the greater part of the running waters that belong to this extensive region, which embraces upwards of two millions of square miles. The Caspian Sea occupies its most depressed portion, and is 81 feet lower than the general level of the waters of the globe. The surface of the Lake of Aral is 31 feet above the same level. Like the Caspian and Aral, both of which are salt, the smaller lakes comprehended within this area are principally salt. The basins of Lake Chad and Lake Ngami, in the African con-
tinent, exhibit, similarly. systems of river drainage which have no outlet to the sea.

79. The New World contains, on a much less extensive scale, two regions of which the drainage is wholly inland. One of these is the great basin or plateau of Utah, to the west of the Rocky Mountains, which includes the great Salt Lake and other smaller basins. The other includes the basin of Lake Titicaca, situated on the highest plateau of the Andes, and enclosed between their stupendous masses upon either side. The waters of Lake Titicaca, unlike those of all other continental basins, are fresh; but the river Desaguadero, which issues thence, is finally lost in the salt marsh of Uros, to the southeast.

80. The Caspian is remarkable as being not only the largest continental basin in the world, but also as receiving the longest of all continental rivers, the Volga—which is, besides, the longest of European rivers, continental and oceanic. Besides the Volga, this great inland sea receives several other considerable rivers, such as the Ural, Terek, and Kur. Rising in the Valdai Hills, at an elevation of only 633 feet above the level of the Caspian, into which it flows, the Volga has an extremely slight fall (an average of about 3½ inches per mile), and, consequently, a singularly gentle current. Besides, its channel is unobstructed by rocks or shoals; its volume is increased by numerous tributaries; it is, therefore, navigable in summer almost to its source. In winter it is frozen over, and sledges and carriages take the place of steamers and barges. Canals connect this great highway of Russian commerce with the rivers that enter the White Sea, the Baltic, and the Black Sea. The Ural rises on the eastern slopes of the Ural Mountains, and enters the Caspian about 200 miles north-east of the delta of the Volga. It is navigable for small vessels. Both the Ural and Volga swarm with fish—the salmon and sturgeon fisheries on the lower Volga are extremely valuable. The Terek and the Kur descend from the Caucasus; the former drains the northern slopes of this great range, and the latter the southern. The chief tributary of the Kur—the Aras—collects the drainage of the northern section of the Armenian highland.

81. The adjacent basin of Aral receives two considerable streams, the Amu and the Syr, the ancient Oxus and Jaxartes. The Amu flows from the Victoria Lake (erroneously called Sir-i-kol), on the Pamir Plateau, at an elevation of 13,900 feet above the sea level. The Syr rises under the name of Naryn in the Thian Shan Mountains. Within the mountain-region both these streams are joined by numerous affluents, so that they become navigable for several hundred miles by small steamers. A deserted bed of the Amu may be traced across the desert which intervenes between its present channel and the eastern shore of the Caspian, through which a portion, if not the whole, of its waters formerly flowed, and into which it will most probably again be diverted. East of Lake Aral is another great inland basin, Lake Balkash, receiving numerous streams.

1 Captain Trotter, 1876.
from the northern slopes of the Thian Shan. The drainage of Eastern Turkestan (enclosed on three sides by mountain-ranges—north by the Thian Shan, west by the Pamir, and south by the Kuen-lun, and opening on the east into the great sandy desert of the Gobi) is necessarily inland. The surplus waters of the Tarim or Erghen, which is fed by numerous streams from the encircling mountains, are poured into the great marshes of Lop-nor, in the very centre of the continent. There are several other smaller isolated basins, such as the Ike-aral, fed by the Jabkan in the Altai region, and the Kara-kul, fed by the Zerafshan in Western Turkestan, between the Oxus and Jaxartes.

82. In Africa there are two remarkable regions of inland drainage, one north, the other south of the equator. In the former, the vast, variable, and shallow lagoon known as Lake Chad, receives from the south the Shary, by several mouths, and occasionally overflows, by the Bahr-el-Ghazal, to a remarkable depression called the Bodele, crossed by Nachtigal in 1878. Whether the Uelle discovered by Schweinfurth is connected with the Shary, or discharges its waters into the Congo, is as yet undetermined. One fact, however, seems to be proved, that is, the close proximity, if not an actual communication, between the basins of the Shary and the Benue. Dr. Barth is of opinion that in less than fifty years European boats will keep up a regular intercourse between Lake Chad and the Atlantic. The other inland-drainage area referred to is that of Lake Ngami, on the northern borders of the Kalahari Desert, in South Central Africa. The Ngami receives the waters of the Tioghe River, which, under the name of Cubango, rises in the Mossambaa Mountains, and in the rainy season overflows by the Zouga into a series of salt pans, or, according to Dr. Holub, occasionally into the Shasha, an affluent of the Limpopo.

83. In North America the principal region of inland-drainage is the "Great Basin of Utah." The Great Salt Lake, which lies at an elevation of 4,200 feet, receives a stream from the smaller expanse of Lake Utah, and also the Bear River from the Uintah Mountains, which, with the Wahsatch Range, divide this basin from that of the Californian Colorado. In South America the Altiplani de the Andes is similarly drained into the great Lake of Titicaca, the surplus waters of which are discharged by the river Desaguadero into the salt lake, or rather marsh, of Aullagas or Uros, 200 miles to the south-east. Besides the overflow from Lake Titicaca, the Desaguadero receives the waters of numerous streams that flow from the inner slopes of the surrounding cordilleras.

84. Lakes.—Lakes are in most cases connected with rivers, either as occurring in the course of river-valleys, or as the ultimate recipients of running streams. They owe their formation, in the vastly greater number of cases, to the agency of running water, in combination with the characteristic contour and relief of the adjacent land. Many of the basin-shaped expanses which occur in hilly regions have been at some former period the beds of lakes, which have become drained of their waters, either by a sudden and violent bursting of the barrier which confined them, or by the slower agency of running streams in eroding the softer strata of the soil. Some lakes are merely receptacles for
the collection of rain, and neither receive nor discharge any stream: the lakes found in many instances within the craters of extinct and dormant volcanoes are of this description. But in by much the greater number of cases, lakes are connected with running streams, either in the way of ingress or egress, or both combined. The lakes in our own island—Windermere, Ulleswater, and others—are examples of this. Each of them receives one or more streams from the surrounding high grounds, and gives issue to a stream at the lower extremity of its basin. A constant current is thus generated through the whole body of water, which preserves its freshness and purity.

85. One important classification of lakes—and perhaps the most important—is into fresh-water lakes, and those of which the water is salt. The former class includes all (or nearly all) lakes that discharge a stream of water—that is, all lakes which possess an outlet. The latter comprehends those lakes which have no channel of discharge—that is, no outlet for their waters. Windermere, Loch Lomond, the Lake of Geneva, are among examples of the former class: the Dead Sea, the Lake of Aral, and the Caspian Sea (which is only distinguished by the appellation of "Sea" from its superior magnitude) are of the latter description. Yet the classification of lakes into fresh and salt cannot be regarded as wholly dependent upon the question of outlet. Lake Chad, in the heart of the African continent, is a body of fresh water; but no permanent outlet has yet been discovered, though receiving the waters of the Shary and other considerable streams. The exceptions, however, are exceedingly rare, and, as a general rule, it may be said that lakes which discharge a running stream are fresh, while those that have no outlet are salt.

86. The depth of lakes undergoes a gradual diminution, from the continued deposition of sediment in their beds, as well as, in some instances, from a secular contraction in the area covered by their waters. The Rhone enters the upper end of the Lake of Geneva as a muddy torrent, and re-issues from its lower extremity as a limpid stream, having deposited in the bed of the lake the sediment and other impurities with which its waters were charged. In greater or less degree, the same cause operates in the case of all lakes into which running streams discharge. The contraction in the area of bodies of inland water is exemplified in the case of the Caspian, the extent of which appears to have sensibly diminished within the historic period, owing, probably, to excess of evaporation over the influx of water from the rivers which it receives.

87. No other part of the world exhibits fresh-water lakes on so extensive a scale as the North American continent. Besides the great inland seas that belong to the basin of the St. Lawrence, all the northern part of the great plain—from the shores of Hudson Bay to the foot of the Rocky Mountains—exhibits a labyrinth of lakes and connecting river-channels. South America is remarkably deficient in lakes: that of Titicaca, on the highest plateau of the Andes, is the most considerable. The largest fresh-water lake in the Old World is Lake
Baikal, in Siberia—the "Holy Sea" of the Russians, by whom its waters are regarded with superstitious reverence.

88. The African continent, though in many parts arid, contains some extensive collections of inland water, two of which—the Victoria and Albert Nyanzas—belong to the basin of the Upper Nile, and have fresh water. The Congo also drains numerous lakes—Tanganyika, Bemba or Bangweolo, Moero, Kamolondo, &c. The great Lake Nyassa is drained by the Shire into the Zambesi; the adjacent Lake Shirwa has no outlet. Lake Tanganyika was for a long time supposed to have no outlet, although its waters are fresh, while the waters of all other lakes without outlets are salt. It is now, however, definitely proved that the Lukuga carries the surplus waters of the lake to the Congo.

89. Of salt lakes, the most remarkable is the Dead Sea, from the extraordinary quantity of saline matter contained in its waters, which exceeds in more than sevenfold ratio that found in the waters of the ocean, and from the unparalleled depression below the general level of the earth's surface which its bed exhibits. The water of the Dead Sea has 25 per cent. of its weight composed of saline substances, amongst which muriate of soda (common salt) occupies the largest place. No living thing can exist in the intensely salt and bitter water of this lake. The surface of the Dead Sea is 1,300 feet lower than that of the Mediterranean. Its maximum depth is 1,148 feet, so that the lowest portion of its bed is upwards of 2,400 feet below the general level of the earth's surface.

90. The principal lakes in each division of the globe, classified according as they are salt or fresh, are enumerated in the following tables. The figures in the first column give the area of each lake in English square miles; those in the second column its elevation above the sea level in feet; or, in the instances where the sign minus (—) is affixed, its depression below that level:

<table>
<thead>
<tr>
<th>SALT LAKES</th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td>Caspian (Russia, Persia, Turkestan)</td>
<td>130,000 83</td>
</tr>
<tr>
<td>Aral (Russia, Turkestan)</td>
<td>26,000 31</td>
</tr>
<tr>
<td>Balkash (Russia)</td>
<td>7,600</td>
</tr>
<tr>
<td>Urumiyah (Persia)</td>
<td>1,800 4,300</td>
</tr>
<tr>
<td>Van (Asiatic Turkey)</td>
<td>1,600 5,647</td>
</tr>
<tr>
<td>Tengri-nor (Tibet)</td>
<td>1,800</td>
</tr>
<tr>
<td>Koko-nor (do.)</td>
<td>1,500</td>
</tr>
<tr>
<td>Lop (Chinese Turkestan)</td>
<td>1,300</td>
</tr>
<tr>
<td>Bahketteaun (Persia)</td>
<td>620</td>
</tr>
<tr>
<td>Zurrah (Afghanistan)</td>
<td>1,600</td>
</tr>
<tr>
<td>Koj-hissar (Asia Minor)</td>
<td>570 2,850</td>
</tr>
<tr>
<td>Dead Sea (Syria)</td>
<td>360 —1,298</td>
</tr>
<tr>
<td>Balaton, or Platten See (Hungary)</td>
<td>250 918</td>
</tr>
<tr>
<td>Niesiedler See (Hungary)</td>
<td>150 360</td>
</tr>
<tr>
<td>Jelton (Russia)</td>
<td>130</td>
</tr>
<tr>
<td>Keroun (Egypt)</td>
<td>130</td>
</tr>
<tr>
<td>Assal (Abbyssinia)</td>
<td>90 570</td>
</tr>
<tr>
<td>Shirwa (East Africa)</td>
<td>900 1,800</td>
</tr>
<tr>
<td>Great Salt Lake (United States)</td>
<td>1,800 4,200</td>
</tr>
<tr>
<td>Uros (Bolivia)</td>
<td>2,000 12,357</td>
</tr>
</tbody>
</table>

1 "Nyanza," of which Nyassa is only another form, is a generic term, applicable to any body of inland water, large or small.
### FRESH-WATER LAKES

#### IN AMERICA

<table>
<thead>
<tr>
<th>Lake Name</th>
<th>Area (sq km)</th>
<th>Depth (m)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Superior (United States)</td>
<td>32,000</td>
<td>556</td>
</tr>
<tr>
<td>Michigan (United States)</td>
<td>24,000</td>
<td>573</td>
</tr>
<tr>
<td>Huron (United States)</td>
<td>20,000</td>
<td>573</td>
</tr>
<tr>
<td>Erie do. do.</td>
<td>9,600</td>
<td>565</td>
</tr>
<tr>
<td>Ontario do. do.</td>
<td>6,300</td>
<td>282</td>
</tr>
<tr>
<td>Champlain (United States)</td>
<td>500</td>
<td></td>
</tr>
<tr>
<td>Great Slave (Hudson Bay Territory)</td>
<td>12,000</td>
<td></td>
</tr>
<tr>
<td>Great Bear do.</td>
<td>10,000</td>
<td></td>
</tr>
<tr>
<td>Winnipeg do.</td>
<td>9,000</td>
<td>628</td>
</tr>
<tr>
<td>Winnipegoos do.</td>
<td>8,000</td>
<td></td>
</tr>
<tr>
<td>Athabasca do.</td>
<td>3,000</td>
<td></td>
</tr>
<tr>
<td>Deer L. do.</td>
<td>2,400</td>
<td></td>
</tr>
<tr>
<td>Manitoba do.</td>
<td>2,100</td>
<td></td>
</tr>
<tr>
<td>Wollaston do.</td>
<td>1,900</td>
<td></td>
</tr>
<tr>
<td>Lake of the Woods do.</td>
<td>1,500</td>
<td></td>
</tr>
<tr>
<td>Utah (United States)</td>
<td>150</td>
<td>4,300</td>
</tr>
<tr>
<td>Nicaragua (Central America)</td>
<td>3,500</td>
<td>128</td>
</tr>
<tr>
<td>Managua do.</td>
<td>430</td>
<td>156</td>
</tr>
<tr>
<td>Yojoa do.</td>
<td>150</td>
<td>2,050</td>
</tr>
<tr>
<td>Chapala (Mexico)</td>
<td>1,000</td>
<td></td>
</tr>
<tr>
<td>Titicaca (Peru and Bolivia)</td>
<td>3,800</td>
<td>12,847</td>
</tr>
<tr>
<td>Putos (Brazil)</td>
<td>5,000</td>
<td></td>
</tr>
</tbody>
</table>

#### IN ASIA

<table>
<thead>
<tr>
<th>Lake Name</th>
<th>Area (sq km)</th>
<th>Depth (m)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Baikal (Siberia)</td>
<td>14,800</td>
<td>1,793</td>
</tr>
<tr>
<td>Kossogol (Mongolia)</td>
<td>4,500</td>
<td>5,600</td>
</tr>
<tr>
<td>Tong-ling (China)</td>
<td>2,000</td>
<td></td>
</tr>
<tr>
<td>Zaisang (Chinese Turkestan)</td>
<td>1,800</td>
<td></td>
</tr>
<tr>
<td>Poyang (China)</td>
<td>800</td>
<td></td>
</tr>
<tr>
<td>Tai-bou do.</td>
<td>700</td>
<td></td>
</tr>
<tr>
<td>Bouka-nor (Tibet)</td>
<td>1,000</td>
<td></td>
</tr>
<tr>
<td>Goukchea, or Sevan (Russian Armenia)</td>
<td>500</td>
<td>6,300</td>
</tr>
<tr>
<td>Tiberias (Syria)</td>
<td>76</td>
<td>-328</td>
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<tr>
<td>Manasarowar (Tibet)</td>
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<tr>
<td>Issyk (Russian Turkestan)</td>
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<tr>
<td>Sir-l-kol Turkestan</td>
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#### IN AFRICA

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<tr>
<th>Lake Name</th>
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<th>Depth (m)</th>
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<tr>
<td>Chad (Soudan)</td>
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<tr>
<td>Tzana, or Demebe,</td>
<td>1,400</td>
<td>6,270</td>
</tr>
<tr>
<td>(Abyssinia)</td>
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<tr>
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<tr>
<td>Albert Nyanza do.</td>
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<tr>
<td>Taunganyika (South Africa)</td>
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<td>1,830</td>
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<tr>
<td>Nyassa do.</td>
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<td></td>
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<tr>
<td>Ngami do.</td>
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#### IN EUROPE

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</thead>
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<tr>
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<td></td>
</tr>
<tr>
<td>Omega do.</td>
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<tr>
<td>Wener (Sweden)</td>
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<td>Saima (Russia)</td>
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<tr>
<td>Peipous do.</td>
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<td>Enara do.</td>
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<td>Mask do.</td>
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<td>Awe (Scotland)</td>
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<tr>
<td>Ulleswater do.</td>
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<tr>
<td>Killarney (Ireland)</td>
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</table>
EXAMINATION QUESTIONS.

1. Explain the terms river-basin, watershed, and delta. Give some examples of rivers that form deltas.

2. Name some rivers which are distinguished by a considerable average fall; also some which exhibit an opposite condition.

3. On what conditions does the volume of water belonging to rivers depend?

4. Give some examples of the respective capability of some well-known rivers for navigation.

5. What is meant (in the case of rivers) by the bore?

6. Of the great ocean-basins, which receives the greater number of the large rivers of the globe?

7. Give some account of the Arctic river-system.

8. Describe in general terms the Atlantic river-system.


10. Describe as fully as possible the course of the Rhine, Danube, and Rhone.

11. Give some account of the river St. Lawrence. What is the distinguishing characteristic of its basin?

12. What rivers of South America fall into the Atlantic?

13. Give some account of the Amazon and Orinoco rivers. What channel forms an union between the two?

14. Give some account of the river Nile, and of its annual inundations. What has been ascertained within late years respecting its sources? Name the other African rivers flowing into the Atlantic.

15. Give some account of the river Mississippi—its length, extent of navigation, affluents, &c.


17. Mark on the map the extent of land drained into the Indian Ocean.

18. Describe the Murray—the chief river of Australia.

19. Describe the three great rivers of India—Brahmaputra, Ganges, and Indus.

20. What regions of inland drainage belong to the Old and New Worlds respectively?

21. In what two great classes may lakes be divided? Name some examples of each class.

22. In what countries are, respectively, the following lakes—Urumiyah, Zurrah, Assal, Athabasca, Nicaragua, Baikal, Maeiär, and Maggiore?
IX.

THE ATMOSPHERE.

1. The air, or atmosphere, is an invisible fluid which surrounds the globe, covering land and sea alike, and reaching from the surface of the earth upwards to a height of at least seventy to one hundred miles. This fluid medium, or aerial ocean, is necessary to the maintenance of both vegetable and animal life, and forms the indispensable condition to the existence of man, as of every other animal. Atmospheric air is inhaled by us in every breath that we draw, and, after fulfilling its proper functions in the vital organisation of our bodies, is again exhaled in an altered form, for the purpose of playing a further part in the great economy of the natural world. It is thus that everything in nature is continually taking part in the admirable series of transformations of which the world of nature is composed. "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 statures; 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 mangolias of the Susquehanna, and the great trees that skirt the Orinoco and the Amazon, the giant rhododendrons of the Himalaya, contributed to it, and the roses and myrtles of Cashmere, the cinnamon-tree of Ceylon, and the forests, older than the flood, buried deep in the heart of Africa, far beyond the Mountains of the Moon. The rain we see descending was thawed for us out of the icebergs which have watched the polar star for ages, and the lotus-lilies have soaked up from the Nile, and exhaled as vapour, snows that rested upon the summits of the Alps."¹

2. Composition.—According to the analyses of Dumas and Boussingault, the air is a mechanical mixture of two gases, oxygen and nitrogen, in the proportion of 20'81 to 79'19 by volume, or 23'01 to

¹ Dr. George Buist.
76'99 by weight. But other gases and substances are almost universally present in very minute quantities—carbonic-acid gas varying from 0'03 at sea to even 0'24 in crowded cities. Aqueous vapour is also present, in variable quantities, together with traces of ammonia, &c. The healthiness of the air in any place is indicated by the presence of ozone, which seems to be an active form of oxygen. It must be remembered that these elements of which the air is composed are not chemically combined, but only mechanically mixed, and that the relative proportions of the two chief gases (oxygen and nitrogen) are the same in all parts of the earth, and at any elevation.

3. Density.—Among other properties of the air is that of density, or weight. It presses upon everything on the earth's surface, with a force equal to nearly fifteen pounds to the square inch. This pressure undergoes progressive diminution with every stage of ascent above the ordinary level of the earth, and, with the diminished pressure exerted by its own weight, the air becomes, in its higher strata, more and more tenuous, or rare. This increased rarity of the air becomes painfully noticeable in the ascent of high mountains, and is often accompanied by difficulty of breathing, with other symptoms that have been frequently described by travellers.

4. Movements.—It is the movements of the atmosphere that make its presence sensible to man, as to others of the earth's inhabitants, and these movements are a consequence of the readiness with which air yields to every pressure, and expands or contracts its volume with every variation of temperature. Wind is simply a portion of air in motion—air, that is, which is passing from one region of the atmosphere to another region. Warm air is specifically lighter than cold air. Hence, if from any cause a given portion of air has its temperature raised above the average temperature of the air with which it is in contact, it has at once a tendency to rise above the lower strata of the whole body of adjacent atmosphere, while its place is taken by the cooler portions of surrounding air. Two currents of air, or winds, are thus generated—an ascending current of warm air, and a horizontal current of cool air; and the movements thus called

1 This pressure is not absolutely uniform, even at the level of the sea. Recent observations have conclusively shown the existence of a diminished pressure in high latitudes of the southern hemisphere. This diminution appears to be greatest within the belt comprehended between 40° and 60° S. lat. Beyond 60° the decrease appears (from the observations made by Sir James Ross) to be less considerable. Maury attributes this diminution of atmospheric pressure in high latitudes south of the equator to excess of aqueous vapour, and, with it, of latent heat, within those regions—an inference justified by the fact that the ocean extends in nearly unbroken continuity round the globe between the parallels referred to.
into being will continue in force until the general equilibrium is restored. The ascending current of warm air gradually parts with its heat as it reaches the upper strata of the atmosphere. Again, a sudden rise of temperature, that is, an accession of heat, causes air to expand in volume, while, on the other hand, a diminution of temperature occasions it to contract. Any such alteration in the volume of air necessarily affects the condition of adjacent portions of the entire body of atmosphere, and currents of air, or winds, are set in motion thereby. The relative dryness, or moisture of the air, is another condition which affects its density, and tends, in consequence, to set its different portions in motion. Any accession of moisture adds to the weight of the air, as any abstraction of its contained moisture diminishes its density. Warm air is capable of holding in suspension a greater quantity of moisture than cold air, and this capability for holding moist vapour increases up to the point of saturation; at this point, any diminution of temperature involves condensation of the vapour held in suspension, and produces rain.

5. The prevailing currents of the atmosphere, or winds, constitute an important feature in the climate of any country, and it belongs to Physical Geography to explain—in so far as they are capable of explanation—the prevalent winds which distinguish great regions of the globe. Such explanation is more easily made in regard to the warmer latitudes of the earth, where alone the direction of the winds is constant, than might be at first supposed by those whose personal experience is limited to such countries as Britain, and other temperate lands, where the variable condition of the atmosphere is the well-known subject of common observation and remark. But within those parts of the globe which experience a vertical sun, and for a few degrees beyond the exact line which marks the limit of the sun’s vertical influence on either side of the equator, the conditions either of perennial calm, or of currents of air that constantly blow in one given direction, are the uniform characteristics of climate.

6. That such atmospheric conditions should be limited to the lower latitudes of the globe is readily accounted for, when we consider the vastly greater power of the sun in those regions, due to the vertical (or nearly vertical) rays which the great luminary there throws upon the earth. It is from the sun that all the heat of our globe’s surface is derived, and we accordingly regard the sun as the great cause of all variations in temperature which different regions of the earth experience. The various distribution of land and sea, and the varying
angle at which the sun's rays meet the surface of either, account for
difference of heat and other conditions of climate. These conditions
are naturally marked out with most distinctness in regions where the
agency of heat is experienced with most intensity—that is, within the
limits of a vertical (or nearly vertical) sun.

7. The line of the tropic marks the precise limit of the sun's vertical
rays; but the actual amount of heat experienced upon one side of that
line differs in scarcely perceptible measure from that felt immediately
on its opposite side, for the gradations between heat and cold—like
those between light and darkness, or between spring and summer—
are incapable of being marked by the precise lines which the mathe-
matician draws upon his diagram, or marks out upon the artificial
globe. The heat of intra-tropical regions passes, by successive gra-
dations, into the cool temperature of the middle latitudes, as the last
does into the cold of the regions that lie around the poles; but the
stages of this passage are gradual. Hence the influences of a vertical
sun prevail for a few degrees beyond the line which mathematically
marks the limit of our great luminary's strictly vertical rays. In
other words, the sub-tropical regions, for a few degrees on either side
of the torrid zone, share the characteristics of that zone, not merely
as concerns temperature, but as respects all the phenomena of meteoro-
logy, and their external limit varies with the alternate presence of
the sun to the northward or southward of the equator.

8. Let us see how the above considerations apply to the great
conditions of climate which distinguish—1st, The regions of almost
perennial calm; 2nd, Of constant winds, blowing uniformly in one
direction; and, 3rd, Of periodical winds, the precise and well-known
direction of which recurs with each returning season:

9. The Calm Latitudes.—Throughout a zone of a few degrees in
breadth, which extends round the globe in the neighbourhood of the
equator, and the limits of which undergo a certain amount of variation,
dependent on the sun's passage to the equinox, the variation of tem-
perature throughout the year is confined within very narrow limits,
and the result is a general prevalence of calms—that is, of undist-
turbed atmosphere. Wind is air set in motion, mainly by the exis-
tence of different conditions of temperature between adjacent bodies
of air—of colder and denser air pressing against warmer and lighter
air, and taking the place which is left vacant by the latter, as it rises
into the higher regions of the entire aérial sea. Between the heated
air of the tropics in general, and the comparatively cooler air of the
regions lying some distance north and south of the tropics, for example, there is a very manifest difference as to temperature, as well as in regard to other conditions; but for a few degrees in the immediate neighbourhood of the equator there is no such obvious difference, and, consequently, nothing to occasion disturbance (temperature alone being considered) in the general equilibrium of the atmosphere. Hence the prevalence of calms in that region. Within the parallels of 8° or 10° on either side of the line, the angle at which the solar rays reach the earth is at no time more than a few degrees from the perpendicular, for the equator divides the total amount of angular difference which is involved in the entire yearly path of the sun.

10. The average breadth of the calm latitudes—or the Zone of Calms, as it is the custom, in books and maps, to term it—may be stated at about six or seven degrees. The mid-line of this zone does not coincide with the equator, for the reason that the equator does not represent the line of the earth's highest temperature, owing to the preponderance of land in the northern hemisphere. Hence the Zone of Calms is, for the most part, to the northward of the equator—extending, with varying seasonal limits, from about the first to the seventh or eighth parallel of north latitude. But the limits oscillate with the sun’s passage of the equinoct, and consequent place in the heavens vertically over either side of the equator. “In July and August,” says Maury, “the Zone of equatorial Calms is found between 7° north and 12° north—sometimes higher; in March and April, between latitudes 5° south and 2° north. . . . . This belt of calms travels during the year, back and forth, over about 17° of latitude, coming further north in the summer, where it tarries for several months, and then returning so as to reach its extreme southern latitude some time in March or April.” It thus moves over more than double its average breadth, and forms, in fact, an oscillating belt of the globe, within which belt the predominating condition of the air is that of intense and nearly unvarying heat, accompanied by a stillness that is only broken at rare intervals.

[The calm latitudes are the dread of the mariner, whose ship is often delayed for weeks together within their limits. The wearisome and tantalizing nature of this delay can, perhaps, only be adequately appreciated by those who have experienced the monotony attendant on a calm in mid-ocean, when, with a still and glassy sea around, a glittering atmosphere, and a burning sun overhead, the sails hang idly by the yards, and the vessel makes no appreciable progress. The often-quoted words of “The Ancient Mariner” possess literal truth:—

“The sun came up upon the left,
Out of the sea came he;
And he shone bright, and on the right
Went down into the sea.

* * * * *

“Down dropp'd the breeze, the sails dropp'd down;
’Twas sad as sad could be;
And we did speak, only to break
The silence of the sea.
"Day after day, day after day,
We stuck, nor breath nor motion,
As idle as a painted ship
Upon a painted ocean."

But the prevailing calm of these latitudes is disturbed, at uncertain intervals, by the sudden gale which springs up—probably under electrical influences, for, as we have already intimated, temperature is not the sole agent of disturbance in the atmospheric equilibrium—and under the influence of which the dreaded region is passed. The mariner rejoices at his escape from its limits, and enters a region within which steady and uniform currents of air are experienced, and in which, accordingly, his vessel can make the surest advance on her voyage.

11. The Trade-Winds.—Between the oscillating limit of the zone of calms and the parallel of 28° in the northern hemisphere, on one side of the globe, and between the correspondent limit and the parallel of 25° south latitude, on the opposite hemisphere, there prevail through above two-thirds of the earth’s circumference, steady winds, blowing with almost undeviating uniformity from the eastward. These are the trade-winds. More precisely, the trade-wind of the northern hemisphere is a wind blowing from the north-eastward—that is, a north-east wind. The trade-wind of the southern hemisphere blows from the south-eastward, and is a south-east wind.

12. The extreme north and south limits of the trade-winds, like their limits towards the equator, are not fixed. They fluctuate with the presence of the sun over the northern or southern half of the torrid zone. The trade-wind of the northern hemisphere is perceptible a few degrees further north, during the summer of that half of the globe, than is the case at the opposite season of the year; and the like wind of the southern hemisphere is experienced further to the south, during the time that the sun’s course is between the equator and the southern tropic, than during the half of the year when that luminary is north of the equator. The trade-winds thus form oscillating belts of the atmosphere, divided by a zone of calms, itself also oscillating. But although the external limits of these winds are subject to variation, there is comprehended within them a broad belt—embracing from twelve to fifteen degrees of either hemisphere—within which the winds blow constantly, in the one hemisphere from the north-east, and in the other hemisphere from the south-east.

13. The trade-wind belts stretch round more than two-thirds of the earth’s surface. They comprehend (within the latitudinal limits already defined) the Atlantic and Pacific Oceans, with the countries that lie adjacent to those vast areas of water. In the Pacific, however, their limits are less distinctly marked, and their influence less powerful, to the southward of the equator than to the north of that line. Over the Indian Ocean and its shores, the atmospheric currents follow, during portions of the year, an opposite course, as will be afterwards explained.

14. The trade-winds of the Atlantic and Pacific—blowing constantly, and with almost undeviating steadiness, from the eastward—regulate the course of
the mariner across those oceans. They of course facilitate the passage of either ocean in a westerly direction—that is, from the shores of the Old World to the eastern sea-board of America, or from the western coasts of the New World to the eastern shores of the Asiatic and Australian continents. It was the trade-wind of the Northern Atlantic that carried Columbus to the westward, on the adventurous voyage which resulted in the discovery of the New World, inspiring terror in the breasts of his companions, while in the mind of the great navigator himself it strengthened the assurance of reaching land by pursuing the direction in which his vessels' prows were turned. On a like great occasion, the trade-wind of the Pacific carried Magellan’s ship steadily forward through the ocean which he was the first to cross, and facilitated the earliest circumnavigation of the globe. On the other hand, the same winds compel the return voyage across either ocean to be made in higher latitudes, where westerly winds prevail.

15. It is not merely at sea that the trade-winds are felt: their influence extends over the maritime regions within the tropical belt of the globe, even to a far distance inland. The trade-wind of the Atlantic is felt in the valley of the Amazons as far up as the mouth of the Rio Negro—900 or 1000 miles from the ocean, where it constitutes a steady and regular breeze.

16. Cause of Trade-Winds.—The explanation of the trade-winds is found in the different measure in which the sun’s heat is experienced by regions within or nearly adjacent to the tropics, and by those of higher latitudes. They are currents of air set in motion by the differences of density consequent upon such various conditions of temperature—conditions which are of uniform prevalence, and the result of which is hence also constant.

17. The portions of atmosphere which, in either hemisphere, are heated by the rays of a vertical (or nearly vertical) sun, become, from this higher temperature, specifically lighter than the adjacent columns of air within higher latitudes. They have hence a tendency to rise into the upper strata of the entire body of atmosphere, while the cooler and denser air of higher latitudes is set in motion towards the place left vacant by the ascending currents, and tends to spread over the lower strata of the whole. In other words, the trade-winds are the cooler air of temperate and higher latitudes, in either hemisphere, moving towards the warmer zone of the earth, to replace the rarefied atmosphere of these regions. These currents of cool air become noticeable, as winds moving over the earth’s surface, within a few degrees of either tropic, because, as the neighbourhood of the tropics (and consequently of vertical heat) is approached, the conditions of difference between the atmospheric temperature of different regions of the globe become more strongly marked. Thence through a belt of varying limits on the side of the equator, but averaging about fifteen degrees of either hemisphere, the north-east currents of air which form the trade-wind of the northern half of the globe, and the south-east currents which are the trade-wind of the southern half of the globe, are constant—in so far as the Atlantic and Pacific Oceans, with their shores, are concerned. But as the region of equatorial heat is approached (and through several degrees before the equator is actually
reached) the conditions of atmospheric temperature become, with each degree of
latitude, more and more uniform. The steady current of the trade-wind begins
to fail, and at length altogether ceases. The belt of the calms is entered, where,
through a space comprehending several degrees upon either side of the equator
of temperature, the condition of the atmosphere is one of uniform heat and con-
sequent equilibrium of density, subject only to disturbances connected with
electric agency.

18. An explanation of the westerly course of the trade-winds is found in the
fact of the earth's diurnal rotation. In this respect, what has been said under
the head of oceanic currents is equally applicable to atmospheric currents, or
winds. If, instead of rotating on its axis, the earth were at rest, we may assume
that the currents of air which advance from polar and temperate latitudes towards
the equator would follow the direction of the meridian—that is, the wind of the
northern hemisphere would be a north wind, and the like wind of the southern
hemisphere would be a south wind. But the atmospheric currents of high
latitudes possess a lower rate of axial motion than belongs to the regions towards
which they are advancing, and hence—left in some degree behind the eastwardly
motion proper to those parts—they acquire a westwardly direction: that is, the
wind of the northern hemisphere, instead of a north, becomes a north-east wind,
and the wind of the southern hemisphere, instead of being a south, becomes a
south-east wind.1

19. To sum up, we may say that the trade-winds, like the currents
of the ocean, are due, firstly, to the sun—that is, to the different
measure in which the solar heat is distributed on the globe's surface;
and, secondly, to the earth's axial rotation, which affects the direction of currents in the aërial ocean in manner precisely analogous to that
in which it affects the like currents in the aqueous ocean. In truth,
the ocean of water, and the ocean of air—in contact with one another,
and possessing many properties in common—act and re-act upon one
another, mutually imparting their respective temperatures, move-
ments, and other conditions. This is only one among the instances
of mutual harmony—one of the many mute sympathies—which
abound in the natural world.

20. The explanation of the trade-winds above given is essentially the same as
that offered, upwards of a century and a half since, by the astronomer Halley,
and afterwards added to by Hadley (Philos. Transac. 1735). This explanation

1 A north-east wind, it will be remembered, has a direction towards the south-west,
and, similarly, a south-east wind blows towards the north-west. A wind is spoken of by
reference to the quarter whence it blows: thus, by a north wind is meant a wind blowing
from the north. The reverse is the case with the currents of the ocean, which are always
referred to the direction towards which they flow. A northerly current is a current
setting towards the north. The equatorial currents of the Atlantic and Pacific are
westerly currents—that is, they set to the westward. The trade-winds of the same
oceans have the same general direction, but their distinctive names as winds, are de-
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has been adopted, with trifling modification, by nearly all subsequent writers on the subject. But the existence of the Belt of Calms appears unaccountably to have been a source of difficulty; whereas it surely follows, from the very assumption of difference of temperature and consequent density in adjoining atmospheric columns as the cause of winds setting from colder to warmer latitudes, that within latitudes of uniform (or nearly uniform) heat, and consequent uniform density, there will be no appreciable motion. Writers on this subject appear to have forgotten that it is not the absolutely high temperature, per se, of the torrid zone which occasions winds, for if the same condition of atmospheric temperature prevailed over the entire globe, there would be uniformity of density, and consequently no impelling cause of wind. It is the difference of comparative temperature and consequent density between adjacent regions of the whole aerial ocean that sets currents of air in motion. This difference is most marked, upon the earth's surface, about those parallels where the contrast between conditions of heat consequent on a nearly vertical sun, and those proper to temperate latitudes, is first distinctly noticeable—that is, within a few degrees of either tropic. It becomes less and less noticeable as the region of greatest and most equable heat is approached. The atmospheric currents consequently fail as the equator of temperature is neared. The trade-wind, long a steady breeze, becomes gradually uncertain: light and fluctuating winds take its place, as either pole-star sinks nearer and nearer to the horizon; at length the wind fails altogether, and uniform calm succeeds.

21. It has often been said, in the vain attempt to furnish any other than the above simple explanation of the calm belt, that the north-east and south-east trade-winds of the opposite hemispheres meet one another, and so neutralize one another's action. But there is, in truth, no such meeting. The trades begin to fail, as has been just observed, long before the calm latitudes are actually reached; and the calm belt, like the inner limits of the trades themselves, continually moves up and down with the transit of the sun from one side of the equinox to the other.

22. The Monsoons are winds which blow over the Indian Ocean, and the countries adjacent to its waters. In general terms, it may be said that they prevail within the same latitudes as those over which the trade-winds of the Atlantic and Pacific blow. But the monsoons differ from the trade-winds of the two greater oceans in the fact that they are periodical winds, not perennial. The monsoon blows for half the year from one quarter of the heavens, and for the other half from an opposite quarter.

23. Over the northerly portion of the Indian Ocean—from the neighbourhood of the equator to the shores of the Asiatic continent, including the Malay archipelago and the adjacent China Sea—a north-east monsoon blows during the winter months of the northern hemisphere; that is, from October to March, inclusive. During the summer months—April to September—and within the same limits,
the south-west monsoon blows. Southward from the equator to the neighbourhood of the tropic of Capricorn, the south-east monsoon blows during the winter of those latitudes (April to September): this is exchanged, during the other half of the year, for a north-west monsoon in the neighbourhood of the Australian coasts, and for a north-east monsoon along the line of the African shores. The term monsoon—derived from a Malay word which signifies “season”—expresses the periodical nature of these winds, and indicates to how large an extent the climate of Indian seas and lands is dependent upon their periodical recurrence.

24. It hence appears that, during half the year, the monsoon of the Indian Ocean coincides in direction with the trade-wind of the Atlantic and Pacific—that is, it is on one side of the equator a wind from the north-east, and on the other side a wind from the south-east. During half of the year only does the monsoon exhibit a deviation from the normal course of the atmospheric currents proper to such latitudes, and the general explanation of which has already been given. The smaller limits of the Indian Ocean, and the striking points of geographical distinction between its basin and those of the two other great oceans, readily account for this partial reversal of the atmospheric currents which characterise correspondent latitudes elsewhere.

25. In the case of the Atlantic and Pacific Oceans, we have not only a vastly greater expanse of water, but we have unbroken continuity of water stretching north and south in the direction of the poles. There is, throughout vast spaces, nothing to impede the operation of those natural laws by which the circulation of the atmospheric currents is regulated, and the agency of which is almost uniform over great expanses of water. The Indian Ocean, on the contrary, besides being of greatly inferior dimensions, is closed to the northward by land. The high lands, mountain-ranges, and extensive coast-plains, which shut in the Indian Ocean upon three sides, undergo great variations of temperature with the passage of the sun from north to south declination, or the reverse, and the heated currents of air which rest upon those lands occasion a reversal, during the period of intensest heat, of the winds proper to such parallels.

26. It is during the summer months of either hemisphere that the reversal of the ordinary trade-wind of the tropics occurs. During the half-year from April to September, the sun is vertically over the lands of southern Asia. The intense heat then experienced by these lands occasions the warm and rarefied air to rise, and currents of cooler air from the adjacent sea set in to take its place. It is thus that a south-west monsoon is generated on the Indian shores, and prevails, with more or less intensity, over large portions of the adjacent ocean, including the islands of the Eastern Indies. With the return of the sun to the south of the equator, the ordinary trade-wind (that is, the north-east monsoon) resumes its place, for the cause of excessive heat and consequent atmospheric disturbance is then withdrawn.

27. Again, during the months between October and March, the summer of the southern hemisphere, the glowing rays of a vertical sun, shining upon the acid
plains of North-Western Australia, occasion excessive heat and consequent rarefaction. The warm air of these regions ascends, and the currents of cooler air which set inland from the adjacent sea constitute a north-west monsoon. The like cause produces, in the vicinity of the East African shores, a north-east monsoon. But when, with the returning winter of the southern hemisphere, the sun has again passed to the northward of the equator, the south-east monsoon, the ordinary trade-wind of southern latitudes, resumes its place.

28. The sun is thus the cause of the monsoons, as of the trade-winds of the Atlantic and Pacific Oceans. The monsoons, in reality, are nothing more than those winds, reversed during half the year, by a cause of which ready explanation is found in the geographical conformation of the lands and seas within which they prevail.

29. Change of the Monsoon.—The change from the one monsoon to that from an opposite quarter is not accomplished at once. The breaking-up of the monsoon, as it is termed, is attended by thunderstorms and other meteorological phenomena, which prevail during some weeks, until the setting-in of the coming monsoon is fairly accomplished. The nature of these changes, and the general characteristics of the monsoon itself, are admirably depicted in the following passage, by a master-hand:

"Meanwhile the air becomes loaded to saturation with aqueous vapour drawn up by the augmented force of evaporation acting vigorously over land and sea: the sky, instead of its brilliant blue, assumes the sullen tint of lead, and not a breath disturbs the motionless rest of the clouds that hang on the lower range of hills. At length, generally about the middle of the month, but frequently earlier, the sultry suspense is broken by the arrival of the wished-for change. The sun has by this time nearly attained his greatest northern declination, and created a torrid heat throughout the lands of southern Asia and the peninsula of India. The air, lightened by its high temperature and such watery vapour as it may contain, rises into loftier regions, and is replaced by in-draughts from the neighbouring sea, and thus a tendency is gradually given to the formation of a current bringing up from the south the warm humid air of the equator. The wind, therefore, which reaches Ceylon comes laden with moisture, taken up in its passage across the great Indian Ocean. As the monsoon draws near, the days become more overcast and hot, banks of clouds rise over the ocean to the west, and in the peculiar twilight the eye is attracted by the unusual whiteness of the sea-birds that sweep along the strand to seize the objects flung on shore by the rising surf.

"At last the sudden lightnings flash among the hills and sheet through the clouds that overhang the sea, and with a crash of thunder the monsoon bursts over the thirsty land, not in showers or partial torrents, but in a wide deluge, that in the course of a few hours overtops the river banks, and spreads in inundations over every level plain.

"All the phenomena of this explosion are stupendous: thunder, as we are accustomed to be awed by it in Europe, affords but the faintest idea of its over-
powering grandeur in Ceylon, and its sublimity is infinitely increased as it is faintly heard from the shore, resounding through night and darkness over the gloomy sea. The lightning, when it touches the earth where it is covered with the descending torrent, flashes into it and disappears instantaneously; but when it strikes a drier surface, in seeking better conductors, it often opens a hollow like that formed by the explosion of a shell, and frequently leaves behind it traces of vitrification. In Ceylon, however, occurrences of this kind are rare, and accidents are seldom recorded from lightning, probably owing to the profusion of trees, and especially of cocoa-nut palms, which, when drenched with rain, intercept the discharge, and conduct the electric matter to the earth. The rain at these periods excites the astonishment of a European; it descends in almost continuous streams, so close and so dense that the level ground, unable to absorb it sufficiently fast, is covered with one uniform sheet of water, and down the sides of acclivities it rushes in a volume that wears channels in the surface. For hours together the noise of the torrent, as it beats upon the trees and bursts upon the roofs, flowing thence in rivulets along the ground, occasions an uproar that drowns the ordinary voice, and renders sleep impossible."

30. The monsoons of the Indian Ocean are not divided by any such distinctly-defined belt of calms as separates the opposite trade-winds of the northern and southern Pacific and Atlantic. The south-east monsoon of the southern Indian Ocean passes gradually into the south-west monsoon, which prevails at the same time in the northern half of that ocean. Nor is the season of change from the one monsoon to the other precisely the same over all parts of that ocean. Indeed, the Indian Ocean, from the geographical conditions already adverted to, is exposed in much higher measure than either of the other oceans to the disturbing influences consequent upon proximity to land, and its winds are hence affected in a vastly greater degree by local conditions. Thus the Indian monsoon, the Arabian and East African monsoon, and the monsoon of north-western Australia, assume in each case a direction which is dependent upon the geographical position and contour of the lands whence they derive their distinguishing names. In the Red Sea, the monsoons follow the direction of its shores, and blow, for six months of the year alternately, up and down its long and trough-like valley, confined and guided in their passage by the mountain-chains which bound it upon either side.

31. We have hitherto spoken of the monsoons only in connexion with the Indian Ocean. But, in truth, a monsoon, or season-wind—which is what the word monsoon means—is experienced upon a large portion of the West African coasts, and thence far out into the mid-Atlantic, within the proper region of the Atlantic trades. The

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1 Sir E. Tennant.
evidence of this is one among the many valuable results due to the Wind and Current Charts of Maury, and the cause of it is precisely the same as that which occasions the monsoon of the Indian coasts. Between the equator and the parallel of 13° north, the intense heat of a vertical sun, acting upon the western coasts and adjacent interior of the African continent, occasions a reversal of the ordinary wind of that region. The intensely-heated atmosphere of the land, owing to superior rarity, ascends, and the cooler air of the neighbouring sea sets in to fill its place. The monsoon thus generated lasts as long as the sun remains to the northward of the equator. Further to the south, a like phenomenon accompanies, in those localities, the passage of the sun into south declination. The influence of these monsoons extends to a distance of a thousand miles or more from land, the entire space within which they prevail forming a cuneiform (or wedge-shaped) region in the midst of the Atlantic, the base of which rests upon the African continent, while its apex is within ten or fifteen degrees of the mouth of the Amazons.

32. A similar reversal of the trade-winds of the North Pacific occurs off the western shores of Central America, capable of explanation in precisely like manner—due, that is, to the excess of heat which the summer sun brings to the adjacent lands, and the consequent rarefaction and rising of the currents of air over those lands. This, and the like instance of the West African monsoons, show in the most striking manner how powerfully the land is affected by the sun's heat, and to how wide a distance the atmospheric movements which are generated by such influences extend over the adjacent seas. Even such limited tracts of land as the Society and Sandwich Islands have a marked influence upon the winds experienced over the surrounding waters. They interfere, says Maury, with the trade-winds of the Pacific very often, and even turn them back, for westerly and equatorial winds are common at both groups, in their winter time.

33. Land and Sea-Breezes.—Upon the coasts of most countries that are within the warmer latitudes of the globe, there occur daily, at or shortly before the hour of early dawn, and towards the approach of sunset, breezes that blow respectively off the shore or from off the adjacent waters. The former is known as the land-breeze; the latter as the sea-breeze.

34. These refreshing movements of the air are not confined to countries within, or even very near to, the tropics, though they are more powerful in the case of countries that are within the torrid zone
than in the case of other lands. But they are felt upon the coasts of
the Mediterranean, and in even much higher latitudes than those of
the Mediterranean, during the warmer portions of the year. The
hour at which they begin to be perceptible is not the same in all
localities; but, speaking generally, the land-breeze begins to be felt
about an hour before sunrise, and the sea-breeze towards the early
evening, as the time of sunset approaches. During the mid-day hours
the intense heat of the atmosphere, accompanied by general calm and
almost perfect repose of the animal world, is painfully felt by all
residents in warm countries, and the cooling sea-breeze which sets in
as the sun approaches the horizon is welcomed with intense delight.
To the sojourner in Indian lands, it is the signal for out-door exercise,
and is accompanied by a general re-awakening of the outer world of
nature. The dweller on the African or Australian coasts equally
rejoices in its refreshing power. The mariner within Indian seas,
frequently becalmed during the stillness of the night-watch, finds
like relief in the breeze which blows off the land with the approach
of early morning.

35. The land and sea-breezes are due to a cause strictly analogous
to that which produces the monsoon of eastern seas—that is, the
influence of the sun heating in various measure the lands and seas, and
with them the superincumbent air. Successive movements are
generated in the atmosphere according as different portions of the
whole acquire, with difference of temperature, various degrees of
density. During the hours of mid-day heat, the air over the land
becomes relatively hotter, by many degrees, than the air which is
above the adjacent water, for it is the well-known attribute of land to
experience much greater extremes of temperature than water does.
As afternoon, with its sultry temperature, advances, this continued
heat occasions the land-air to form an ascending current, while the
cooler (and relatively denser) air from the neighbouring waters flows
in to take its place. This cooling breeze is an effort of nature
to restore equilibrium in the atmosphere, the heavier portions of the
whole body of air assuming the place of lower strata, and the lighter
portions spreading over the superior regions. This effort continues
until the desired balance is attained, and, with the approach of mid-
night, the air is again calm and settled. But during the night, while
the water retains a nearly uniform temperature, the land rapidly
parts with its heat, so that the air over the land becomes at length
colder than that over the water. This latter, therefore, relatively
the warmer of the two, tends to rise, while the cooler air of the land
fills its place. A wind blowing from off the land is thus generated. In some localities this blows during great part of the night. But the period of its commencement varies in different places, and the intervals of calm between both land and sea-breezes are often of uncertain duration.

["These sea-breezes"—we transcribe the quaint but expressive language of Dampier—"do commonly rise in the morning about nine o'clock, sometimes sooner, sometimes later. They first approach the shore so gently, as if they were afraid to come near it; and oftentimes they make some faint breathings, and, as if not willing to offend, they make a halt, and seem ready to retire. I have waited many times, both ashore, to receive the pleasure, and at sea, to take the benefit of it. It comes in a fine, small, black curl upon the water, when as all the sea between it and the shore not yet reached by it is as smooth and even as glass in comparison. In half an hour's time after it has reached the shore, it fans pretty briskly, and so increaseth gradually till twelve o'clock—then it is commonly strongest, and lasts so till two or three a very brisk gale. . . . These winds are as constantly expected as the day in their proper latitudes, and seldom fail but in the wet season. On all coasts of the main, whether in the East or West Indies, or Guinea, they rise in the morning, and withdraw towards the evening; yet capes and headlands have the greatest benefit of them, where they are highest, rise earlier, and blow later. Land-breezes are as remarkable as any winds that I have yet treated of; they are quite contrary to the sea-breezes; for those blow right from the shore, but the sea-breeze right in upon the shore; and as the sea-breezes do blow in the day and rest in the night, so, on the contrary, these do blow in the night and rest in the day, and so they do alternately succeed each other. For when the sea-breezes have performed their offices of the day, by breathing on their respective coasts, they, in the evening, do either withdraw from the coast, or lie down to rest. Then the land-winds, whose office is to breathe in the night, moved by the same order of Divine impulse, do rouse out of their private recesses, and gently fan the air until the next morning; and then their task ends, and they leave the stage. There can be no proper time set when they do begin in the evening, or when they retire in the morning, for they do not keep to an hour. . . . They both come and go away again earlier or later, according to the weather, the season of the year, or some accidental cause, from the land; for on some coasts they do rise earlier, blow fresher, and remain later, than on other coasts. . . . These winds blow off to sea, a greater or less distance, according as the coast lies more or less exposed to the sea-winds; for in some places we find them brisk three or four leagues off shore, in other places not so many miles, and in some cases they scarce peep without the rocks, or, if they do sometimes in fair weather make a sally out a mile or two, they are not lasting, but suddenly vanish away, though yet there are every night as fresh land-winds ashore at those places as in any other part of the world. . . . The sea-breezes, indeed, are very comfortable and refreshing; for the hottest time in all the day is about nine, ten, or eleven o'clock in the morning, in the interval between both breezes; for then it is commonly calm, and then people pant for breath, especially if it be late before the sea-breeze comes, but afterwards the breeze allays the
heat. However, in the evening again, after the sea-breeze is spent, it is very hot till the land-wind springs up, which is sometimes not till twelve o'clock, or after."

36. The land and sea-breezes repeat, on a scale of diurnal variation, the phenomena shown by the monsoons on a scale of yearly change. They show how readily the atmosphere yields to the slightest pressure, and how powerful an influence on the laws of climate, and, with them, on the condition of mankind, is exercised by every change, of temperature or otherwise, to which it is subject. Similar winds—alternating from opposite quarters of the heavens—are experienced in inland districts, as on the banks of the Tapajos river, in South America.

37. Winds of High Latitudes.—Within the middle and higher latitudes of the globe, from the outer limits of the trade-winds of either hemisphere towards the poles, no such uniformity is found in the direction of the atmospheric currents as belongs to the winds of tropical seas and lands. With every advance into higher latitudes, not only does the sun’s heat become less considerable, and the cause of periodical or constant movement in the atmospheric currents less intense in its action, but there is increasing variation in the respective length of day and night at opposite seasons. Moreover, it is in the north temperate zone of the earth that the land bears the largest proportion to the water,¹ and that—at least in so far as the lands and seas within the northern half of the globe are concerned—the elements of uncertainty in the movements of the air are found in largest measure. The entire problem of atmospheric change, so to speak, is more complex under such conditions than is the case within tropical latitudes, and under conditions of tropical heat.

38. Within the temperate latitudes of the great oceans, however, from about the parallel of 30° on either side to the neighbourhood of the polar circles, the prevailing winds are from the westward. These westerly winds of middle latitude are by no means correspondent in regularity to the steady easterly breezes of tropical seas. They are, on the contrary, of uncertain occurrence and duration, often separated by intervals of contrary movements in the air, and at all times liable to interruption by violent disturbance, or storm. Still, in the average of any given period of time, the westerly winds experienced within such localities exceed those that blow from other quarters of the heavens in a large numerical ratio. These westerly winds facilitate the return across the great ocean of ships which have made their outward voyage, in the opposite

¹ See the table on page 14. It is only in the north temperate zone that the land and water cover nearly equal portions of space. Elsewhere the water is everywhere greatly in excess of the land.
direction, under the influence of the trade-winds of the tropics. The homeward voyage from the North American sea-board to the shores of Western Europe; the route from China and Japan to the western coasts of the New World; or the like voyage, within southern parallels, from Australia towards the shores of Chili; and the outward voyage from Britain, past the Cape of Good Hope, through the southerly latitudes of the Indian Ocean, to the coasts of Western Australia, are accomplished by aid of the winds of middle latitudes, blowing, for the most part, from the westward.

39. The limit between these prevailing westerly currents of air and the trade-winds is marked by an interval of uncertain breezes and frequent calms. These calms of temperate latitudes are generally experienced by the mariner about the 28th or 30th parallels of either hemisphere (somewhat nearer to the equator in the southern than in the northern half of the globe), as he approaches the region of the well-known trades, or easterly breezes, which belong to warmer skies.

40. The prevailing westerly winds of middle latitudes are to be regarded, in the great system of atmospheric movements, as compensating currents for the trade-winds of lower parallels. They are, in fact, the returning currents of tropical latitudes, which, by their ascent into the higher regions of the air, have become cooled in temperature, and, from the density thus acquired, sink towards the surface of the earth, to replenish the source whence the constant indraught of the tropics is supplied. Their eastwardly direction is accounted for by the same consideration which explains the eastwardly movements of the ocean-currents within similar latitudes, and which explains the westwardly course of the intra-tropical currents of air and water alike—that is, the earth's rotation. Advancing, on their return course, from equatorial towards polar regions, their normal direction is along the meridian; but the superior rate of rotary movement, acquired in the regions whence they originally set out, gives them an advance to the eastward beyond that proper to the latitudes in which they are travelling. Hence the general direction of north-east (that possessed by a S.W. wind) within the middle latitudes of the northern hemisphere, and that of south-east (proper to a N.W. wind) within similar latitudes south of the equator. The conflict which, in their return to the earth's surface, from the prior condition of upper currents, they have to maintain with the surface currents of air advancing towards the equator—to feed the trade-winds regions—accounts, at least in some measure, at once for the irregularity of movement which generally marks the winds of middle latitudes, and for the frequent and violent gales to which such latitudes are liable.

41. The easterly winds of the tropics, and the prevailing westerly winds of middle latitudes, alike form parts of a great system of atmospheric movements, through the agency of which the whole body of air is maintained in circulation, and its uses to man thereby developed in their fullest proportions. The general direction of these movements is the same in the aerial ocean as in the ocean of water, and may,
for the sake of a broad generalisation, capable of being easily retained in the memory, be thus expressed:

(1) Within the warmer latitudes of the globe, the winds, and also the oceanic currents, have a prevailing direction to the westward.

(2) Within middle latitudes, the prevailing winds, and also the principal oceanic currents, have a direction to the eastward.

(3) Within high latitudes, the prevailing direction, of winds and currents alike, is from the poles towards the equator—that is, from north to south in the northern hemisphere, and from south to north in the southern half of the globe.

Over the land, with its infinitely-varied surfaces, the winds, especially within temperate and higher latitudes, exhibit conditions of change which are much more irregular and complicated, and which form a highly important feature in the general subject of climate.

42. Rotary Storms.—The rotary storms which occur, at uncertain intervals, in particular latitudes, are to be included amongst the exceptional phenomena of atmospheric change. They prevail, however, over larger areas than was formerly supposed, and perhaps belong to a general system of atmospheric movements in which electric and magnetic influences fill an important place. The hurricanes of the West Indies, the tornadoes and cyclones of the Indian Ocean, and the typhoons of the China Sea, are winds of this description. Within the southern hemisphere, the direction of the rotating circle is always found to correspond to the movement of the hands of a watch (i.e., from west to north, east, and south): to the north of the equator, the circle of wind follows an opposite direction (or west to south, east, and north.) By a knowledge of this law, combined with careful observation of the track usually taken by such storms, mariners are enabled to avoid some of the dangers incident to their occurrence. The destruction which they occasion, however, within maritime tracts exposed to their influence, as well as upon the high seas, is at times fearfully great.

43. Water-Spouts.—Water-spouts are another form in which the rotary movements of the air are manifested. In the case of these phenomena, a taper column of cloud, descending from above, is joined by a spiral column of water which winds upward from the agitated surface of the sea, the two together forming, by their union, a continuous column which moves over the sea. Water-spouts seldom last longer than half an hour. They are more frequent near the coast than on the high seas; and are more commonly seen in warm climates.
EXAMINATION QUESTIONS.

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1. What is the atmosphere? Mention one of its properties. What amount of pressure does air exert on the earth's surface?

2. How are winds occasioned? In what parts of the world is the direction of the wind perennial, or nearly so?

3. What is meant by the calm latitudes? State the average breadth of the Zone of Calms.

4. What are the Trade-Winds? State their precise direction.

5. How are the Trade-Winds to be accounted for? What analogy is there between them and the Currents that prevail within similar latitudes?

6. What are Monsoons? In what parts of the world are they experienced?

7. What conditions of the Indian Ocean (in respect of shape, &c.) account for its winds being different from those of the Atlantic and Pacific, in correspondent latitudes?

8. Give a description of the Summer Monsoon, as experienced on the coasts of Ceylon.

9. What are "Land and Sea Breezes?" Where are they experienced, and to what causes are they due?

10. In what respect do the winds experienced in higher latitudes differ from those that prevail within the warm belt of the globe? How is the difference to be explained?

11. From what direction do the prevailing winds of high latitudes blow?

12. How is the limit between the Trade-winds of the torrid zone, and the prevailing westerly winds of temperate latitudes, marked? And at what distances north and south of the equator?

13. State, as a general summary, the prevailing direction of the winds, (1st) within the warmer latitudes, (2nd) within middle latitudes, and (3rd) within high latitudes.

14. What are Rotary Storms? Within what parts of the globe do they occur, and by what names are they known in different regions?

15. What are water-spouts?
X.

CLIMATE.

1. All the conditions of Physical Geography which have been described in the foregoing chapters enter into the constitution of Climate, and combine to produce it as their joint result. The arrangement of land and water, the areas of drainage possessed by different countries, the geological formation of the soil, the position and movements of the ocean, the phenomena of the atmosphere, and, above all, the various measure in which the direct solar heat is communicated, constitute the conditions of physical climate. And according to the various degrees in which such conditions are combined in the case of any particular region, is it suitable for the abode of man.

2. Among the conditions above glanced at, those which are most important, and which determine, for the most part, the general characteristics of the climate of the country, are the three following:

(1) Latitude, which determines the angle of the sun's rays, and the respective lengths of day and night at opposite seasons.
(2) Height above the sea-level.
(3) Distance from the ocean.

There are many other things to be considered in the endeavour to account for the special features of climate in the case of any given region, but the three here named are of vastly superior importance to any others, and too much attention can hardly be bestowed on their thorough comprehension.

3. Influence of direct Solar Heat.—The hottest parts of the globe are those upon which the rays of the sun descend vertically. This is the case only within the torrid zone; that is, through a belt of the globe which is 47° across, or 23½° on either side of the equator, and which is marked on either hand by the lines of the summer and winter tropics. Within this zone the sun is always vertically over some point or other at the hour of noon—at which time the sun's
place in the heavens is highest. Between the tropics and the poles, the sun, even at mid-day, is never vertical, and the amount of difference between the sun's place in the heavens and the place of a point directly over the head of an observer becomes greater with every successive parallel. The amount of this difference, too, becomes greater or less, for the time being, according as the sun's place is to the north or south of the equator—that is, according as the season of summer or winter prevails in either hemisphere. The subjoined diagram illustrates this:

[Supposing the line P P' to represent the earth's axis, and the points C C', in either hemisphere, the place of the tropics, the annual range of the solar path in the heavens, in the direction of latitude (or declination), will be represented by the arc S' S''. Within some portion or other of the terrestrial zone C C' the mid-day sun will always be vertical. The point S represents the sun's place at the time of the equinoxes, or when the sun is directly over the equator; S' is the sun's place at the time of the summer solstice (i.e., the summer of the northern hemisphere), S'' his place at the winter solstice. But in those parts of the earth which are within the arcs C P, C' P', or within the temperate and frigid zones, the sun's rays are at no time vertical, and the difference between their angle of contact with the earth and a perpendicular line becomes greater with every degree of latitude. The height of the mid-day sun, at any given locality, is determined by the place of the sun in the heavens, for the time being, either on the same side of the equator as the place itself, or on the opposite side. Within the tropics, the amount of this difference constitutes an item of much less consideration than within the temperate zones, and it is of less importance in the case of the latter than in the instance of the frigid zones. The summer and winter of the temperate and frigid zones, as we have seen, are the result of the sun's place in north or south declination, and the difference between the temperature of those seasons is vastly greater within the frigid zones than elsewhere. For a distance of 23 1/2° round either pole, indeed, the sun is alternately above or below the horizon for periods which increase from twenty-four hours to half the year in duration.]

4. The amount of direct heat communicated by the sun is greatest when received immediately from overhead, and it becomes less and less according as it reaches objects in a direction more and more oblique. A large amount of this heat is, under this latter condition, lost in the transmission, by dispersion amongst the atmospheric
medium through which it has to pass. The difference we daily experience between the heat of a noonday sun, and that derived from the slant beams of a morning or evening sun, illustrates this truth; and the difference between the heat communicated by the sun of our midsummer and midwinter skies is another example of it.

5. The mean temperature of any place is the average of the heat experienced throughout the year, as determined by observations made at frequent intervals during every day of the year. Similarly, the mean seasonal heat is the average of the observations made during any given season. Latitude determines the amount of this, in so far as the direct measure of solar heat communicated to the earth's surface is concerned—other conditions being, for the present, disregarded. The hottest parts of the globe are those within the torrid zone, and the amount of mean yearly heat gradually decreases from the equator towards the poles, the regions within the polar circles being the coldest parts of the globe.

6. The relative length of the day and night at opposite seasons becomes an element of increasing importance in the determination of climate with every advance in the direction of the poles. Within the tropics it is comparatively unimportant. At the equator, day and night are uniformly of twelve hours' duration, and in no part of the torrid zone does the excess above this period at one season of the year, or the amount short of it at the opposite season, exceed seventy minutes. At the tropics the longest day is little more than thirteen hours, and the shortest nearly eleven hours. But in latitude of London (51°30') the longest day is nearly seventeen hours in duration, and the shortest only seven hours. Under the Arctic circle, the longest day is of exactly 24 hours' duration, the sun at the period of the summer solstice remaining above the horizon for the whole of that period, while the winter solstice exhibits a night of corresponding length. Within the polar circles, again, there are alternate periods of continuous sunshine, or continuous darkness, which increase in measure from twenty-four hours to six months, as the place of the pole is reached.

7. During the whole time that the sun is above the horizon at any place, his rays are communicating heat to the earth, while during the whole period of darkness the ground is parting (by the process of radiation) with the heat which it had previously possessed. Hence, within high latitudes, the long days and short nights of one season, and the short days and lengthened periods of darkness of the opposite
season, involve extremes of heat and cold which are unknown to other localities, and which become increasingly marked with increasing proximity to the poles. During the long day of the polar summer, (a season brief in the total, as compared with the entire year, but marked by a duration of continuous sunshine which has no parallel elsewhere,) there is an accumulation of heat which explains the high temperature of Arctic lands in the months of July and August; as the lengthened absence of the sun at an opposite period of the year accounts for the extreme cold of an Arctic winter.

[The importance of the respective lengths of day and night at opposite seasons, in the determination of climate, is recognised in the scheme adopted by the geographers of antiquity, who divided the earth’s surface into a series of climates,\(^1\) regulated by the increasing length of the longest day. Between the equator and the polar circle, there were twenty-four such climates, in each of which the length of the longest day exceeded by half-an-hour the length of the similar period in the adjoining zone. The breadth of these zones shows a continual increase from the equator towards the higher latitudes. Between the polar circle and the pole, there are six similar climates, which, however, differ in the length of the longest day by periods of a month.]

8. Latitude, then, serves as the first and chief measure of climate, in regard alike to the mean temperature of the year, and the extreme temperature of the respective seasons. Places experience a less amount of heat, on the average of the year, in proportion as they are within higher parallels of latitude—that is, the temperature undergoes progressive diminution from the equator towards the poles. The range of annual temperature, or extreme amount of difference between the heat of summer and the cold of winter, increases in the same direction.

(1) The torrid zone is a region of great heat throughout the year, and with comparatively little difference (in so far as temperature alone is considered) between opposite seasons.

(2) The temperate zones are regions of decreasing heat, on the average of the year, but with an increasing range of seasonal temperature, the difference between the extremes of summer and winter becoming more and more marked with increasing distance from the tropics.

(3) The frigid zones are regions of low temperature on the average of the entire year, and of excessive winter cold, contrasted by a brief season of extreme summer heat.

9. Influence of Elevation.—Of the secondary causes which determine climate, the most important is—comparative elevation. The temperature of the air falls with increasing altitude above the mean level of the earth’s surface, and a degree of cold which is below the freezing point may be reached, in every part of the globe, by an ascent of a few thousand feet. The decrease of temperature, however, is far

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\(^1\) Greek, klima, a region, or climate.
from preserving an uniform ratio. Its *average* rate—at least within the lower regions of the atmosphere—has been generally regarded as about 1° (Fahrenheit) for every 250 feet of ascent. But in Mr. Glaisher's balloon-ascent great inequalities in this regard were experienced—a rise of temperature sometimes occurring at great elevations, upon passing through particular strata of the air, followed by a subsequent decrease of heat. A succession of warm and cold currents of air—the former at heights, upon some occasions, of 14,000 feet—were sometimes passed through. The ratio of decrease in the atmospheric temperature, again, differs in the seasons of summer and winter, and also with the succession of day and night. It appears probable that about sunset the temperature varies but little up to a height of two thousand feet.

10. These inequalities, however, constitute mere modifications (though highly important ones) of the general fact of decreasing heat with increase of elevation. The traveller who climbs a lofty mountain-range, or mounts the sloping side of a high plateau, passes from the warm temperature of the lowland plain or sheltered valley, through successive degrees of increasing cold, until he at length reaches a region of unmelting snow and eternal frost.

11. The height of the *snow-line* (as the commencement of the snowy region is called) varies with the latitude. Some examples of this have been given in a preceding page.¹ In the equatorial Andes, it is not found until an altitude of 15,800 feet has been reached. In the Alps it occurs at 9,000 feet, and in the mountains of Scandinavia at less than half that elevation. Below the line of unmelting snow, there is also, in the case of most mountain-ranges, a region of winter snows only, the thawing of which, with the return of a summer sun, contributes largely to swell the beds of the torrents which abound in mountain-lands. This zone between the snow-lines of winter and summer coincides, in the Alps, with the upper portion of the glacier-region.

[The position and general configuration of any extensive mass of land, as well as its mere elevation, affect its temperature in a large degree. The snow-line is higher on the northern face of the Himalaya, towards the plateau of Tibet, than on the southern slope of the mountains,—a seeming anomaly, but one which is of easy explanation. The Himalaya and adjacent plateaus, like all elevated mountain-lands, constitute a great region of condensation. The moist vapours with which the prevailing winds of that region are laden—imbibed in their passage across the Indian Ocean—arrives first at the southern face of the mountain-chain,]

¹ Strachey: *Journal of Royal Geographical Society*, vol. xxii., p. 70.
and are there stripped, by the process of condensation, of the chief part of their contained moisture. Hence the deposit of snow upon the southern face of the mountains greatly exceeds that which falls upon their northward slopes, and it descends to correspondently lower levels.\(^1\) Radiation from the surface of an elevated table-land perhaps tends in some measure to increase the height of the snow-line upon the mountain slopes by which it is immediately bordered.]

12. **Climate of Table-lands.**—Regions of elevation, in whatever latitude, have therefore a temperature which is lower, by many degrees, than that of less elevated lands under similar parallels. Such regions as Tibet, Afghanistan, Armenia, Central Spain, Mexico, Quito, and many others, are examples of this upon a large scale; as tracts of ground of even very moderate size—familiar, in numerous cases, to our personal experience—are on a smaller scale.

13. The climate of Quito, though nearly under the line of the equator, is that of the temperate zone; but then Quito is at a level of 9,000 feet above the sea. Tibet experiences a low temperature, though within the same parallels as the Mediterranean coasts; but the plains of Tibet are 13,000 feet above the level of the sea, an elevation nearly as great as that of the summit of Mont Blanc. Mexico exhibits, under the same parallel, three distinct zones of climate—the heated lowland, along the coast of the Mexican Gulf; the cool temperature of the mountain side, from the plain upward to heights of 4,000 or 5,000 feet; and the still lower temperature which belongs to the summits of the interior table-land, at altitudes of from five to nine thousand feet.

14. Again, plateau-regions are exposed, at least within extra-tropical latitudes, to much greater extremes of temperature, at opposite seasons, than are experienced by lands of opposite conformation. Their high and unsheltered elevations experience alternately the scorching heat of a summer’s sun, and the piercing blasts of winter, which sweep over their generally naked surface. The interior of Spain supplies an eminent example of this; the Spanish capital is in summer one of the hottest, and at the opposite season one of the coldest, of European cities. The summer-heat of Madrid sometimes reaches above 110° in the shade! Its mean summer and winter temperatures exhibit a difference of 33°, while the correspondent range of the summer and winter temperatures of Lisbon, at a direct distance of only 300 miles, and differing in latitude by less than two degrees, is little more than 18°. The table-lands of Western Asia supply yet more striking examples. At Teheran, the Persian capital, the power of the summer sun is so intense that flowers blow and wither in a single day. At Furrah, in Afghanistan, says Ferrier, the mid-day heat of summer makes eggs hard, and balls of lead malleable. Again, Erzerum, the chief city of Turkish Armenia, seated in the midst of a plain which is 6,000 feet above the sea, has a summer of tropical heat, and a winter which parallels in severity that of the polar regions.

\(^1\) It should be observed that in the Southern Hemisphere the snow-line is much lower in certain latitudes than in the corresponding latitudes in the Northern Hemisphere. Thus at Admiralty Inlet, South Shetland, in lat. 64°, the snow-line is at sea-level; in the Northern Hemisphere in 64° the line of perpetual snow is at a height of several thousand feet.
15. Proximity to the Sea.—The ocean is a great moderator of heat and cold. Water, as we have elsewhere said, preserves a more equable temperature than land; it becomes less heated by the sun's rays during the hours of daylight, and less cooled below the average when the sun's rays are withdrawn. This equability of temperature is communicated to the air with which any large body of water is in contact, and thence to that which is over the adjacent land. Islands, and maritime countries in general, are hence, for the most part, free from the extremes of heat and cold which often characterise inland regions.

16. Every division of the globe furnishes examples of the superiority of climatic condition which results from proximity to the sea, and of the wide contrast which obtains between the phenomenon of meteorology in the instance of countries so situated, and those experienced in the case of tracts that lie far inland. The climate of Britain, and that of the correspondent latitudes of European Russia, supply one of the most striking of such instances. Edinburgh is in almost the same latitude as Moscow, but while the average temperatures of the summer and winter quarters are at Edinburgh respectively 57° and 38°, the correspondent temperatures of the same seasons as experienced at the old Muscovite capital are 64° and 15°. At Moscow there is a difference of nearly 49° between the mean temperature of summer and the mean of winter; while at Edinburgh the equivalent difference is less than 19°. If, instead of the mean seasonal temperatures, we take the maximum temperatures—that is, the extremes of heat and cold at each locality—the difference is still more in favour of the Scotch metropolis. Who does not recognise, at a glance, the vast superiority of a climate in which the range of heat and cold is preserved within the moderate limits which are familiar to the inhabitants of Britain, as compared with that under which the vast plains of Russia are annually burnt up, or converted, for months together, into a pathless wilderness of snow? Who does not see the numerous train of consequences which must result from such differences, in regard to habits of life, dress, amusements, and social usage of every kind? Yet more, what reader of history will fail to recall the vicissitudes of fortune, affecting the fate of empires, which have derived their colouring from the terrible severities that belong to the climate of the Russian plain? The fate of the Swedish conqueror's army in 1709, and the yet more terrible fate of a greater conqueror's invading army upwards of a century later, tell the same story of suffering, and illustrate the same lesson in respect of the truths of Physical Geography.

1 Hence, among other results, the belief popularly entertained of certain springs, that they are colder in summer and warmer in winter. "The fount that ran by Ammon's shade," (the well-known fountain of the Sun, in the North African desert,) is one of the number. In reality, springs which derive their water from any considerable depth preserve the same, or very nearly the same temperature, throughout the year, while the temperature of their place of issue undergoes considerable variation. Relatively to the air, they are therefore colder in summer, and warmer at the opposite season.
2 Charles XII., at Pultowa.
3 Napoleon I. in the Russian Campaign of 1812.
[One of the ablest of our geologists has shown that the question of the relative distribution of land and sea is the basis of all inquiry respecting the conditions of climate, alike in former eras as in the present chapter of the world's history. If the lands of the earth, instead of being distributed as they actually are, were differently grouped, the whole temperature of the globe's surface would exhibit a different result. If the whole mass of land were grouped within regions proximate to the equator, intense heat would be the result, and the greater part of the globe would be uninhabitable by man. On the other hand, were the whole of the lands grouped in great masses around the poles, an opposite result would ensue, and mankind would be uniformly degraded to the condition of the Eskimo or the Samoide. Large continuous masses of land become, under a tropical sky, regions of excessive heat, and their burning temperature influences the movements and other conditions of the atmosphere for vast distances around. The Sahara of the African continent is a vast natural furnace, the influences of which affect the climate of lands that are a thousand miles away. Happily, the Mediterranean sea intervenes to protect Europe from its worst results. Were the Mediterranean occupied by solid land, what is now southern Europe would be converted into an arid waste, and the smiling shores of Greece and Italy become parched as the regions that form the border of the desert.

The climates of Central Asia repeat the same story of excessive heat and cold, consequent upon removal by vast spaces from the tempering influences of the ocean. There are but two seasons in Mongolia—nine months winter, and three months summer. "In the deserts of Tartary," says Huc, "and especially in the country of the Khalkas, the cold is so terrible, that during a great part of the winter the mercury freezes in the thermometer; and often when the earth is covered with snow, and the north-west wind begins to blow, it drives the avalanches before it, till the whole plain looks like a great white stormy ocean."

17. Continental and Insular Climates.—Eastern Russia, Mongolia, Africa, interior Australia, with many other localities, furnish examples of continental climates, which are climates of extreme heat and extreme cold. Great Britain supplies an example of insular climate, which is a climate of moderate degrees of heat and cold—of summers which are never intense in their heat, and winters which never reach the excessive cold felt in other lands. New Zealand, and, in yet higher measure, Tasmania, display, in the southern hemisphere, similar conditions of comparatively uniform temperature.

[For further examples of insular and maritime climate, we might point to the tracts of land that are found distributed over the waters of the great ocean, within either half of the globe. Nowhere are the advantages of equable temperature more strikingly exhibited than in the case of the South Sea Islands, as the island-groups of the vast Pacific are often called. Polynesia exhibits, within the border of the torrid zone, a climate which is a perpetual spring—the warm spring of

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1 Sir Charles Lyell: Principles of Geology.
the tropics. The thermometer seldom varies more than five or six degrees throughout the year. The heat which ordinarily characterises tropical latitudes is unknown. The breezes from the surrounding sea diffuse a perennial freshness through the air. A succession of fruits and flowers display, throughout the year, the abundant gifts of nature, and all things—save man—realise the attributes of an earthly paradise!]

18. Prevailing Winds.—Among the secondary causes affecting climate, probably none is of greater importance than the direction of prevailing winds. The currents of air are warm or cold, wet or dry, according as they have had their origin in warm or cold latitudes, and have traversed inland tracts, or the expanse of ocean, in their advancing course. With us, and in the northern half of the globe in general, north and east winds are cold and dry, while south and west winds are warm, and often accompanied by moisture. Within the southern hemisphere these conditions are reversed, and the hottest currents of air come from a northwardly direction. The prevailing winds of western Europe are from the west and southwest; and it is to this fact that we must mainly ascribe the high winter-temperature, as well as the comparative freedom from extremes of heat and cold which distinguishes the countries of western Europe. The same cause explains the abundant moisture which belongs to those regions in general, and which distinguishes the western shores of our own islands in a remarkable degree. Such winds have traversed the immense expanse of the Atlantic, and come to the western seaboard of Europe laden with the moist vapours gathered on their course. These vapours, condensed upon the high grounds which line the western side of the British Islands, or, farther to the northward, upon the long chain of the Scandinavian mountains, fall to the earth in copious torrents of rain. In the process of condensation, a vast quantity of latent heat is disengaged, and the temperature is correspondently raised. Warmth and moisture are, indeed, speaking generally, concomitant conditions of European climate, and are especially so in the case of western Europe.¹

¹ "The Pyrenees, the Alps, and the German as well as the Scandinavian mountains," (says Hopkins,) "have their degrees of influence in condensing vapours brought from the Atlantic, and, by the vacua created about them, drawing farther supplies to render western Europe, especially in the parts near the sea, warm in winter. Each locality in this part of the world is, in the cold season, warmed in proportion to the amount of vapour condensed in it. The thickly-shrouded and drizzling atmosphere of the western islands of Scotland, in lat. 58°, constantly giving out heat from condensation, is warmer than that of London in the winter; but then, six times the quantity of rain has been known to fall in the former place than descended in the latter, and more rain has fallen in the Isle of Skye in the month of January than fell in Paris or London in the whole year."—(Journal of Royal Geographical Society of London, vol. 27.)
19. Even in the case of lands which nearly approach the tropic, the influence of prevailing winds in raising or lowering the temperature is strikingly seen. At New Orleans, bordering on the Mexican Gulf, and throughout the adjacent portions of the United States, the winters are often of excessive severity. Cold winds, generated in the higher latitudes of the New World, and blowing for weeks in succession from the northern quarter of the sky, are the cause of this. The generally level interior of the North American continent—a vast lowland plain, bounded only to the east and west by the Alleghanies and the Rocky Mountains—presents no obstacle to the advance of these cold northerly blasts. The middle and eastwardly parts of North America are subject to like influences, in this regard, to the plains of eastern Europe. To the westward of the Rocky Mountains, on the other hand, the conditions affecting climate present greater analogy to those that belong to western Europe.

20. Local Winds.—In the case of many countries, some local wind, of occasional prevalence, forms a marked characteristic of climate. The most remarkable of these local winds are the simoom, the sirocco, the föhn, the harmattan, and the mistral.

The Simoom.—The often-described simoom of the desert is an intensely-heated and dry wind, which raises the temperature like the blast of a furnace, and fills the air with particles of sand, of suffocating quality. The same wind is known in the deserts of Turkestan as the tebbad (fever-wind), the terrible conditions of which are described by the pen of a recent traveller. "The kervanbashi (leader of the caravan) and his people drew our attention to a cloud of dust that was approaching, and told us to lose no time in dismounting from the camels. These poor brutes knew well enough that it was the tebbad that was hurrying on; uttering a loud cry they fell on their knees, stretched their long necks along the ground, and strove to bury their heads in the sand. We entrenched ourselves behind them, lying there as behind a wall; and scarcely had we, in our turn, knelt under their cover, than the wind rushed over us with a dull, clattering sound, leaving us, in its passage, covered with a crust of sand two fingers thick. The first particles that touched me seemed to burn like a rain of flakes of fire. Had we encountered it when we were deeper in the desert we should all have perished. I had not time to make observations upon the disposition to fever and vomiting caused by the wind itself, but the air became heavier and more oppressive than before."  

The Sirocco.—The sirocco of the Mediterranean coasts is the hot wind of the African desert, tempered, before reaching the coasts of southern Europe, by its passage across the great expanse of inland waters. The enervating influences of this wind are well known to the resident on the shores of Sicily, the Italian mainland, or the islands of the Archipelago. The same wind, when it reaches the high mountain-regions of the Apennines and the Alps, is known as the föhn.

The Fohn.—The fohn, or warm south wind, is an important agent in modifying the climate of the higher Alpine region, where its prevalence for a few days in succession causes the snow-line to recede, and is often accompanied by inundations occasioned by the suddenly-melted snows. Its absence during a longer period than usual is attended, on the other hand, by a prolongation of the glaciers into a lower region of the mountain-valleys. The Swiss peasants have a saying, when they talk of the melting of the snow, that the sun could do nothing without the fohn.

The Harmattan.—The harmattan of Senegambia and Guinea is a cold and intensely dry wind, which blows from the north-east during the months of December and January.

The Mistral.—The mistral of southern France possesses similar qualities to the last-named wind, and blows, for days together, down the valley of the Rhone.

21. Winds transport particles of dust, and, with them, the minuter forms of vegetable and animal life, to vast distances. The phenomena known to sailors as red fogs and sea-dust are evidence of this. In the Mediterranean, and also in the neighbourhood of the Cape Verde Islands, showers of dust, of brick-red or cinnamon colour, are sometimes experienced in such quantity as to cover the sails and rigging, hundreds of miles away from land. Amongst this sea-dust, examination with the microscope has detected infusoria and other organisms native to the tropical regions of South America.

22. Minor causes affecting Climate.—Among minor causes which affect climate, and contribute to regulate its conditions in particular localities, the following may be enumerated:—The direction of mountain-chains (or, in their absence, the general slope of the land); the nature of the soil, and the extent to which it has been brought under culture; the direction of prevailing winds; and, in the case of maritime countries, the course and temperature of currents.

1 Sir C. Lyell cites the testimony of M. Denzler, who observes that the fohn blew tempestuously at Algiers on the 17th July, 1841, and then, crossing the Mediterranean, reached Marseilles in six hours. In five more hours it was at Geneva and the Valais, throwing down a large extent of forest in the latter district; while in the cantons of Zurich and the Grisons, it suddenly turned the leaves of many trees from green to yellow. In a few hours new-mown grass was dried and ready for the hay-stack. The snow-line of the Alps has been observed to rise sensibly every day while this wind was blowing. Its influence is not confined to the summer season: in the winter of 1852 it visited Zurich at Christmas, and in a few days all the surrounding country was stripped of its snow, even in the shadiest places, and on the crests of high ridges.

The same wind sometimes dissolves, as with magical celerity, the snows which cover the summits and higher parts of Mount Etna. "I had been told (says Lyell, referring to the year 1828) that I should be unable to ascend to the top of the highest cone till the following spring; but in thirty-six hours the hot breath of the sirocco stripped off from the mountain its white mantle of snow; and I ascended without difficulty."
23. The extent to which the soil has been brought under culture is another of the elements which materially affects the temperature of any particular district. The draining of marshes, and cutting down of forests, which are necessary preliminaries to the use of the plough, tend in most cases to raise the temperature, as well as to improve it in other regards. The winters of central Europe are less severe now than in ancient times, when almost unbroken forests stretched from the skirts of the Alps to the plains bordering upon the Baltic, and the great rivers stagnated in their lower courses through vast swamps, which have long since given way before the labours of the engineer. Our own country has shared in this general amelioration of one of the most important of its physical conditions. The alternate wastes of moor, forest, and fen, which once spread over two-thirds of the surface of Great Britain, have been replaced by the corn-field or the green meadow-land: as the up-turned soil has been exposed to the influence of the sun, and the air allowed to circulate freely through tracts which were formerly darkened by the deep shade of forest growth, the air has been rendered both warmer and drier than it formerly was. The destruction of forests, however, has not unfrequently been attended with prejudicial effects, as in the case of Iceland, which has been rendered sensibly colder from this cause. In tropical lands, the amount of rainfall has sometimes been injuriously diminished by the wasteful cutting down of trees.

24. Direction of Mountain-chains.—The influence of mountain chains upon the climate of adjacent lands is at once obvious. In the case of those which lie in the direction of east and west, the opposite sides of the range meet the rays of the sun at different angles of elevation, and hence receive the direct solar heat in different measure. The northern and southern slopes of the Alps, and the difference between the climate of Switzerland and that of Lombardy, furnish the tritest of examples. Upon one side is the region of the glacier and the avalanche; on the other, that of the corn-field, the olive-ground, and the mulberry-plantation. In one case the snow-line is found at an altitude of 8,000 feet above the sea, in the other it recedes to upwards of 9,000 feet. But this instance, so often referred to, is not seldom misunderstood. If the Alps, as is justly said, shelter Italy from the cold winds of more northerly European latitudes, the cold currents of air which are generated among the higher elevations of the mountain region sweep at times with piercing severity over the plains below, and the winter of Piedmont and Lombardy is often one of great severity.
25. Slope of Land.—The general slope of the land, in the case of any particular country or district, furnishes an example on a large scale, of that which every field or garden illustrates upon a scale of smaller proportions. A western or a southern slope offers, in the case of our own country, more genial conditions of temperature, and consequently greater facilities of ripening the various objects of culture, than an inclination towards opposite quarters of the sky. This is equally true of a county or a province as of a flower-garden or an orchard. The slope of a country is marked out upon the map by the direction of its rivers. In the case of the larger part of Britain, we observe a general slope to the eastward, for the greater number of our rivers discharge into the North Sea. The comparatively low temperature of our eastern coasts, and their exposure to winds blowing from eastern quarters of the sky, are the well-known attributes of that division of the island. The higher grounds which line our western shores, and the lands which slope from them towards the Atlantic waves, enjoy a warmer (as well as a moister) air. The river-basins of France exhibit, with one exception, a general westwardly inclination. The basin of the Rhone, directed to the southward, is under yet more favourable conditions. It is the true region of the olive and the mulberry, while the orange, ripening in the open air, gives evidence of the high temperature which distinguishes the maritime division of the ancient Provence. The valley of the Danube, with its general eastwardly slope, displays—especially in its lower portion—conditions of temperature which are much less favourable than those of the Rhine, though the course of the latter river lies under parallels which are several degrees farther north.

26. Influence of Currents.—The influence of oceanic currents upon climate, in the case of maritime countries, is not without importance. A current of warm water tends to impart warmth to the superjacent and immediately adjoining air, and a cold current the reverse. But this influence, as a cause of perennial mean temperature, has probably been greatly exaggerated. The warm temperature of western Europe has been very commonly ascribed to the influence of the Gulf Stream, without any distinct proof that the water of the Gulf Stream ever reaches the European seaboard—for the north-eastwardly extension of the Gulf Stream, as commonly laid down on our maps, is at least problematical. The cold current from Baffin Bay, flowing immediately along the eastern coasts of North America, perhaps accounts in some measure for the low temperature of that
region, as compared with correspondent parallels on the opposite side of the Atlantic.

27. Distribution of Rain.—The greater or less quantity of rain in any region is a highly important element of its climate. Rain is unequally distributed over the surface of the earth, both as to quantity and as to the seasons of its occurrence. There are parts of the world which are altogether rainless, as there are others which possess a superabundant moisture. As general rules, the three following conditions hold good:

1. Rain is more abundant in warm than in cold countries—i.e., its quantity decreases from the equator towards the poles.
2. Rain is more abundant in maritime tracts than in inland regions.
3. Rain is more abundant in hilly districts and mountain-regions than in lowland regions.

On the whole, more rain falls in the Western Hemisphere than in the Eastern half of the globe. This naturally results from the fact that the western includes a much larger proportion of water than the eastern Hemisphere. The eastern half of the globe is continental, the western chiefly oceanic. It is from the ocean that all rain is primarily, by process of evaporation, derived. Clouds are masses of aqueous vapour, drawn in greatest abundance from those regions where a heated atmosphere, acting upon the expanse of water beneath, most facilitates evaporation—that is, from the regions of tropical heat. The quantity of moisture which air is capable of holding in suspension increases with its temperature. That is, warm air can contain, in the form of aqueous vapour, a greater amount of water than the same body of air at a lower temperature is capable of holding. If air, at any given temperature, and saturated with moisture, becomes exposed to any cooling influence, so that its temperature is lowered, condensation ensues. The aqueous vapour becomes reconverted into water—or, in very low temperatures, into snow or hail.

28. If two bodies of air, possessing different temperatures, but each charged with water up to the point of saturation, come into contact, so as to mingle with one another, rain is produced; for the resultant temperature of the whole becomes lower than the point at which

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1 See page 13.
2 It has been proved experimentally that evaporation takes place at even the lowest winter temperatures—within Arctic latitudes; and that precipitation often occurs even while the air is quite clear. The mutual interchange between sea and air is, in fact, constant.
saturation, without precipitation, can be maintained. Winds effect a continual transfer of portions of the atmosphere from one region to another, and bring rain or drought according as they have traversed vapour-yielding surfaces or otherwise—that is, as they have passed over great expanses of ocean or of land. In greater or less degree, according to their elevation and consequent temperature, all mountain-regions are regions of condensation. That face of a mountain-region towards which the course of prevailing and moisture-laden winds is directed, receives consequently copious floods of rain, while the opposite face of the same chain is often parched and arid. The abundant rains of Norway are derived from the winds which blow from the neighbouring Atlantic Ocean, and have their contained vapours condensed upon the western face of the Scandinavian mountain-chain. In like manner, the south-west monsoon, which blows during six months of the year upon the Malabar coast, comes densely laden with the moist vapours of the Indian Ocean. The long chain of the Ghauts arrests its progress; condensation ensues, and copious floods of rain are poured upon the seaward face of the mountain-region. Exhausted of its moisture, the same wind, or such portion of it as passes the mountain-crest, only reaches the opposite side of the chain as a dry wind. Along the line of the Coromandel coast, on the other hand, the north-east monsoon is accompanied by rain.

29. The maximum fall of rain in hilly regions appears from observation to occur within definite limits of elevation, coincident, as might be expected, with those which mark the ordinary altitude of the rain-clouds. Within warm latitudes, the greatest amount of rain-fall is found at heights between three and five thousand feet above the sea.

30. Dry and Rainy Seasons.—In those parts of the globe where the atmospheric currents, or winds, are either constant or of periodical recurrence—that is, within or near the tropics—the seasons of rain are fixed and unvariable. The year is divided between a dry season and a rainy season. In the former, the sky is unclouded during months together, and the parched ground exhibits all the effects of intense heat, combined with drought. In the latter, the rains fall, for a time, in abundant torrents, with a violence to which the cooler regions of the globe offer no parallel. There are fewer rainy days in the year in warm than in cold countries, but a vastly greater abundance of rain falls within the shorter time than is precipitated during
the whole year within higher latitudes. All the phenomena of atmospheric change are exhibited on a scale of greater intensity within the tropics. Thunder-storms are experienced there on a scale of surpassing grandeur, and are accompanied by floods of rain, which, descending in sheets, within a few hours lay whole tracts of country under water, and convert what is at ordinary times the dry bed of a rivulet into a raging torrent. In some regions—as in the West Indies, for example—there are two wet and two dry seasons annually, as the sun passes and repasses the zenith in his annual path. This is also the case upon the eastern coasts of tropical Africa, south of the equator.

31. Seasons of Rainfall.—Within the tropics, the rains follow the course of the sun—that is, the season of rain coincides, upon either side of the equator, with the period of the sun's highest declination. In the northern half of the torrid zone, the period between September and March is the season of dry atmosphere and unclouded skies; as the sun passes the equinox and approaches daily nearer to the zenith, clouds attend his course, and a rainy season (of longer or shorter duration, in particular localities) succeeds. Southward of the equator, the dry season embraces from April to October inclusive, and the tropical rains fall within the opposite half of the year. The limit of tropical rains, however, does not in all cases precisely coincide with the astronomical boundaries of the torrid zone, though nowhere passing it by more than a few degrees.

32. In the case of extra-tropical regions, the seasonal distribution of rain follows an opposite law, the period of greatest rain being for the most part coincident with the winter months of the year. But it is only within the warmer latitudes of the temperate zones (or in sub-tropical latitudes, as they are called) that the rains are limited, with any strictness, to particular seasons. Elsewhere, rain is more generally distributed throughout the year, though more abundant in some months than in others. The countries of southern Europe, and those bordering the Mediterranean in general, are regions of winter rain, while western Europe is distinguished rather by the abundance of autumnal rains.

33. Annual Rainfall.—The total annual rainfall is said to average 77 inches within the tropical regions of the Old World, and 115 inches in the correspondent latitudes of America. The annual rainfall at a few well-known localities is given, for the sake of comparison, in the following Table—the places being arranged according to their
position in the Eastern or Western Hemisphere, and in the order of their distance from the equator:

<table>
<thead>
<tr>
<th>WESTERN HEMISPHERE,</th>
<th>Inches of rain.</th>
</tr>
</thead>
<tbody>
<tr>
<td>Maranhão (Brazil)</td>
<td>S. lat. 2° 30'  276</td>
</tr>
<tr>
<td>Paramaribo, (Dutch)</td>
<td>N. lat. 5° 45'  229</td>
</tr>
<tr>
<td>Guiana.</td>
<td>N. lat. 12° 8'   126</td>
</tr>
<tr>
<td>Island of Granada</td>
<td>N. lat. 17° 30'  67</td>
</tr>
<tr>
<td>Belize</td>
<td>N. lat. 18° 0'   83</td>
</tr>
<tr>
<td>Kingston (Jamaica)</td>
<td>N. lat. 18° 29'  107</td>
</tr>
<tr>
<td>St. Domingo</td>
<td>N. lat. 18° 35'  60</td>
</tr>
<tr>
<td>Port au Prince</td>
<td>N. lat. 19° 15'  69</td>
</tr>
<tr>
<td>Vera Cruz</td>
<td>N. lat. 20° 57'  22</td>
</tr>
<tr>
<td>Rio Janeiro</td>
<td>N. lat. 22° 50'  48</td>
</tr>
<tr>
<td>Havanna</td>
<td>N. lat. 25° 50'  53</td>
</tr>
<tr>
<td>Newport</td>
<td>N. lat. 26° 50'  57</td>
</tr>
<tr>
<td>Charleston (U.S.)</td>
<td>N. lat. 32° 50'  48</td>
</tr>
<tr>
<td>Washington</td>
<td>N. lat. 38° 53'  35</td>
</tr>
<tr>
<td>Philadelphia</td>
<td>N. lat. 39° 57'  47</td>
</tr>
<tr>
<td>New York</td>
<td>N. lat. 40° 43'  36</td>
</tr>
<tr>
<td>Toroonto</td>
<td>N. lat. 43° 40'  39</td>
</tr>
<tr>
<td>Sitka</td>
<td>N. lat. 57° 34'  88</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>EASTERN HEMISPHERE,</th>
<th>Inches of rain.</th>
</tr>
</thead>
<tbody>
<tr>
<td>Singapore</td>
<td>N. lat. 1° 16'  97</td>
</tr>
<tr>
<td>Madras</td>
<td>N. lat. 18° 5'  48</td>
</tr>
<tr>
<td>Mahabaleshwar</td>
<td>N. lat. 17° 59' 304</td>
</tr>
<tr>
<td>Bombay</td>
<td>N. lat. 18° 57'  80</td>
</tr>
<tr>
<td>Calcutta</td>
<td>N. lat. 22° 34'  81</td>
</tr>
<tr>
<td>Maritzburg (Natal)</td>
<td>S. lat. 29° 35'  70</td>
</tr>
<tr>
<td>Sydney</td>
<td>S. lat. 33° 51'  52</td>
</tr>
<tr>
<td>Adelaide</td>
<td>S. lat. 34° 35'  22</td>
</tr>
<tr>
<td>Melbourne</td>
<td>S. lat. 38° 18'  31</td>
</tr>
<tr>
<td>Pekin</td>
<td>N. lat. 39° 60'  73</td>
</tr>
<tr>
<td>Hakodadi</td>
<td>N. lat. 41° 56'  88</td>
</tr>
<tr>
<td>Rome</td>
<td>N. lat. 41° 58'  59</td>
</tr>
<tr>
<td>Paris</td>
<td>N. lat. 48° 49'  21</td>
</tr>
<tr>
<td>Plymouth</td>
<td>N. lat. 50° 23'  27</td>
</tr>
<tr>
<td>London</td>
<td>N. lat. 51° 35'  24</td>
</tr>
<tr>
<td>Liverpool</td>
<td>N. lat. 53° 24'  24</td>
</tr>
<tr>
<td>Kendal</td>
<td>N. lat. 64° 20'  66</td>
</tr>
<tr>
<td>Edinburgh</td>
<td>N. lat. 56° 57'  24</td>
</tr>
<tr>
<td>St. Petersburg</td>
<td>N. lat. 60° 0'   16</td>
</tr>
<tr>
<td>Bergen</td>
<td>N. lat. 60° 24'  82</td>
</tr>
</tbody>
</table>

34. The torrid zone includes the regions of most abundant rain-fall: in some localities, as Brazil and other parts of tropical America, the immediate neighbourhood of the equator is the seat of almost constant precipitation, the rain rarely intermitting for any period of lengthened duration. Brazil, Guiana, the islands of the West Indies, Central America, and the shores of the Mexican Gulf, in the New World,—the coasts of Guinea and Senegambia, with those of eastern Africa, India and the islands of the East Indies, in the Old World, are among the regions of most abundant rainfall: all of them fall within the zone of tropical rains.

35. Monsoon-rains.—The coasts of eastern Africa, India, and southern China, fall within the region of the monsoon rains. These are uniformly distinguished by the most copious abundance. A description of them, as experienced in Western India, has been quoted in a preceding chapter. In the eastern interior of the African continent, the seasonal changes are equally marked.

1 Mahabaleshwar is a station within the Ghauts, to the southward of Bombay, at an elevation of 4,500 feet above the sea. According to Dr. Buist (Bombay Geographical Society) this extraordinary amount of rain-fall is more than doubled at Cherrapoonjee (lat. 25° 14', long. 91° 45'), a station in the Khassia Hills, to the northeastward of Calcutta. The average fall at this place is said to be 610 inches; above 20 feet occasionally falling in the month of June alone! Cherrapoonjee lies at an elevation of 4,200 feet above the sea. Other mountain-regions, however, supply like instances of excessive rain-fall. In the neighbourhood of Scawfell (Cumberland), a fall of 225 inches has been recorded within the year.

2 See page 167.
36. The rainy monsoon (says Capt. Burton) is here ushered in, accompanied, and terminated by thunderstorms, with occasional hail-falls. Blinding flashes of white, yellow, or rose-coloured lightning play over the firmament for hours uninterruptedly, illuminating the landscape with a vividness which discloses the finest shades of colour, and which renders only the more intense the thick and almost palpable gloom by which they are succeeded. "A deafening roar, simultaneously following the flash, appears to travel, as it were, to and fro overhead; several claps will sometimes sound almost at the moment, and as if coming from different directions; and the same storm will, after the loudest outburst, pass over, and be immediately followed by a second, showing the superabundance of electricity in the atmosphere. When hail is about to fall, a rushing noise is heard in the air, with a sudden coolness, and a strange darkness from the canopy of brownish purple clouds." The quantity of electricity with which the atmosphere is charged is truly astonishing. The rain-fall here is not as in Western India, a steady downpour, lasting sometimes two and three days without a break. In Central Africa, rain seldom endures beyond twelve hours. Night is its normal period of recurrence: the mornings are often wet, and the mid-day is generally dry. Hail-storms are frequent. The sun, during the rainy monsoon, burns with sickly depressing rays, which make the wet earth reek with vapour, like a garment hung out to dry. This, however, is not the unhealthy period of the year. As in India, the season of deadly miasma follows the wet monsoon, from the middle of May till the end of June. The south-west wind gives place to that from the north-east about April, a little later than at Zanzibar. The cold gales and the servid suns then affect the out-spread waters: the rivers, swollen during the weeks of violent downfall that usher in the end of the rains, now begin to shrink, and miry morasses and swamps of black vegetable mud line the low lands whose central depths are still under water. "The winds, cooled by excessive evaporation, and set in winter by the heat, howl over the country by night and day, dispersing through the population colds and catarrhs, agues and rheumatisms, dysenteries and deadly fevers."1

[The conditions described in the above passage, of course, vary in some degree with local circumstances. Everywhere, however, the rainy season of the tropics is one of abundant downfall. A few hours' rain gives abundance to a whole province, and its absence may involve suffering and even starvation to the population of a vast territory.]

37. Rainless Belt.—The interior plains of the Old World, on the other hand, are distinguished by conditions altogether opposite to those above described. A vast and nearly rainless region stretches through the continents of Africa and Asia, between the meridians of 16° west and 118° east of Greenwich, and ranging from the 15th to the 47th parallel. This broad zone of arid lands comprehends the vast expanse of the African sahara, with the extensive deserts of interior Arabia, Persia, and Mongolia. Though not—excepting in

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1 On the Lake-regions of Central Equatorial Africa by Capt. R. F. Burton.
the worst portions of the Sahara—absolutely rainless, yet rain only occurs at uncertain and distant intervals, frequently of several years apart; and intense aridity is the distinguishing feature of the whole region. ¹ Within the African and Arabian wilderness, indeed, the intense heat of the air causes it to absorb at once whatever of moisture may be derived from adjacent lands or seas; and the few light clouds which are occasionally seen over its burning expanse rapidly disappear—dried up, as it were, even while the expectant wayfarer gazes upon them.

38. There are like rainless—or almost rainless—districts in the New World, though of much smaller extent. Some of the interior plains of the Mexican plateau are distinguished by intense aridity, though the maritime portions of that country exhibit an excessive rainfall. But the most remarkable of such tracts in the western half of the globe is found to the southward of the equator, embracing the coast-district of Peru and Bolivia, between the parallels of 4° and 27°. This range of country stretches along the western base of the Andes, between those mountains and the Pacific Ocean. The tract known as the Desert of Atacama falls within its limits. Throughout this extensive range of coast, it is only at rare intervals that a drop of rain refreshes the thirsty soil, the sole moisture being derived from dense mists (or garuas) which occur at certain seasons. Yet the eastern face of the Andes, within the same parallels, is watered by copious rains. The explanation of this, as of so many other conditions of local climate, is found in the direction of the prevailing winds. The currents of air which bring abundance of moisture, and consequent luxuriance of vegetable life, to the Brazilian plains, are the trade-winds of the southern Atlantic, laden with the moist vapours drawn up in their passage over its extensive basin. The high and cold summits of the Andes arrest their further progress to the westward, and condensation ensues; hence the copious floods of rain which are poured down upon one side of the mountain-region, while the other side experiences comparative aridity.

[In some regions of considerable magnitude, a gradual process of desiccation is observed to be in operation, and the diminution or almost total cessation of rain-fall has been productive of serious consequences. This is the case within a large area of Southern Africa, lying between the basins of the Zambesi and

¹ Even within the so-called "rainless" belt, occasional rains occur with extreme violence. "At Jiddah (says the British Consul, writing in 1862) last year, rain fell so abundantly that in the harbour, for the distance of half a mile from the town, the surface of the sea was fresh."
Orange rivers, and embracing the generally arid region to which Lake Ngami belongs. The extent of the last-named lake has undergone sensible diminution in recent times, and a gradual drying-up of its waters is still in progress. There seems good reason to attribute the diminished rain-fall, in such cases, to the wasteful cutting down of trees, and destruction of vegetable life in general, owing to the extensive bush-fires, which frequently spread desolation over vast areas. Trees uniformly attract moisture, and thus promote rain-fall. Numerous instances are known in which the destruction of forests has been followed by diminished moisture,—often by the drying-up of springs, and the ceasing to flow on the part of streams.

39. **Snow.**—When the temperature of the air is at or below the freezing point of fresh water (32° F., or 0° C.), the particles of aqueous vapour are frozen into minute crystals, which unite and form snow-flakes. Upwards of one thousand varieties of snow crystals have been observed, nearly all hexagonal in shape. Snow is from ten to twelve times lighter, bulk for bulk, than water, and is also an admirable non-conductor of heat—thus effectually checking radiation, and protecting vegetation. In the tropics snow never falls, except at extreme elevations; in the temperate zones it falls on the lower grounds in winter only; within the polar circles it covers the land down to the sea-level. The point above which the snow remains unmelted all the year round forms what is known as the **snow-line**, or the line of perpetual congelation. This line rises from sea-level near the poles to about 16,000 feet under the equator. The indefinite accumulation of snow above the snow-line is checked to some extent by evaporation and melting, but chiefly by avalanches and glaciers. When a mass of snow accumulates on a steep slope, or on the edge of a precipice, large portions frequently break off, or sometimes the entire mass is suddenly precipitated into the valley below, overwhelming and destroying everything in its path. **Avalanches**, however, in spite of their magnitude and frequency, afford less relief to the constantly-increasing mass of snow above the snow-line than the vast accumulations of snow, converted by pressure into ice, known as glaciers. In tropical and temperate regions, glaciers occupy the higher recesses and valleys of nearly all the principal mountains, and descend far below the snow-line; in polar lands, which are entirely covered with snow, they reach the sea-shore, and project into the water. Vast pieces constantly break off, and float away, forming the characteristic icebergs of the Polar seas. Those of the Arctic Ocean are carried south as far as the 40th parallel; those of the Antarctic Ocean are found, even in summer, 10 or 15 degrees nearer the equator.
40. **Glaciers.**—It is only within a recent period that the true nature of glaciers has been understood, and that they have been studied with a view to determine their origin and formation, with the nature of their motion, and other conditions. The glacier is an *ice-stream*, or river, originating in those parts of the mountain-region which lie above the snow-line, supplied from above by the snow which falls during each successive season, and most abundantly during the winter. It advances with constant (but unequal) motion down the valley—accompanied, both in front and upon either side, by a mass of loose stone, rock, and various débris, known by the name of a *moraine*. When the lower portion of the glacier recedes, as is often the case during summer, the moraine is left in advance of its course—an enduring indication of the furthest point which the ice-stream has reached. The glaciers of the Alps descend, in many instances, as low as between three and four thousand feet, advancing to the very border of the vineyard or the corn-field. The lower extremity of the Mer de Glace (on the western face of Mont Blanc) is only 3,667 feet above the sea.

41. The surface of the glacier is everywhere *crevassed*—that is, intersected by deep crevasses or rents, which vary from a few inches to many feet in breadth, and are often many hundred feet in depth. The direction of the crevasses is generally transverse to that of the glacier. In length they sometimes stretch quite across the glacier, from one side to the other. Some of the crevasses on the Mer de Glace are probably 2,000 feet in length. The crevasses are, in fact, rents or cracks in the moving body of the ice-current, and are in great measure renewed from year to year.

42. The ice of which the glacier is composed exhibits in many cases a veined appearance—successive streaks of blue alternating with the general structure of the entire mass. This appears to be owing to intense pressure from above—in the same way that a laminated or slaty structure is the result of intense pressure exerted on various kinds of rock formation. The direction of the veins is vertical, or nearly so, to the surface of the glacier, and is at right angles to that of the crevasses. The latter are the result of extreme tension, exerted upon a body which moves over an irregular surface: the laminated structure, of which the veins are the evidence, is due to pressure. The blue colour is due to the expulsion, under such conditions, of the air-bubbles with which the main body of the ice is elsewhere filled, and by which its peculiar whiteness is occasioned.

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1 What gives to a glacier its most peculiar and characteristic feature is, that it does not belong exclusively or necessarily to the snowy region. "The snow disappears from its surface in summer as regularly as from that of the rocks which sustain its mass. It is the prolongation or outlet of the winter-world above: its solid mass is protruded into the midst of warm and pine-clad slopes and greenward, and sometimes reaches even to the borders of cultivation. The very huts of the peasantry are sometimes invaded by this moving ice, and many persons now living have seen the full ears of corn touching the glacier, or gathered ripe cherries from the tree with one foot standing on the ice."—**Forbes**: *Travels through the Alps of Savoy.*
43. The upper portion of the glacier—above the snow-line—is known as the nevé: the ice of which the nevé is composed exhibits a texture less uniform and less compact than belongs to the middle and lower portions of the ice-stream. It consists of alternate layers of granular snow and hard ice.

44. The motion of the glacier exhibits perfect analogy to that of a river. Its rate of advance is greater in the centre than at the sides, and greater at the surface than towards the bottom. The retardation of the sides and bottom results from friction against the rocks with which the ice is there in contact. It moves faster in summer than in winter; but the motion is never wholly interrupted. The mean daily motion of the Mer de Glace, in different portions of its extent, has been ascertained to vary between nine inches and twenty-five inches. The average rate of motion, towards the lower part of the glacier, is, in summer, about 17 inches daily; this diminishes to 13½ inches during the winter. The average rate of motion belonging to the entire ice-stream is perhaps about 500 feet annually. The surface of the glacier undergoes continual changes of level, uniformly becoming depressed during the summer. This is owing mainly to the higher temperature of that season, which thaws the surface of the ice, but is probably aided by other causes.

45. The glacier leaves a permanent record of the course it has taken in the grooves or scratchings (striae) which it makes on the adjacent mountain-side. These marks, found in numerous localities where no glaciers now exist—as in parts of Wales and Scotland, as well as in many other lands—indicate the former existence of glacial action, and (as well as the ancient moraines, which are met with in similar localities, and under like conditions) attest the changes of climate which the surface of the globe has undergone.

46. Isothermal Lines. — The varying conditions of climate, and the diverse causes to which these varieties are due, assume their most obvious manifestation when places which have correspondent temperatures are connected upon a map by means of lines drawn so as to pass through them. Such lines are called isotherms—that is, lines of equal heat.

47. If temperature were regulated solely by latitude, it is obvious that all places at similar distances from the equator would enjoy like

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1 The theory of Professor Forbes, in regard to glaciers, is thus expressed (Travels in the Alps of Savoy, p. 365):—"A glacier is an imperfect fluid, or a viscous body, which is urged down slopes of a certain inclination by the mutual pressure of its parts." This theory, in the belief of the present writer, fully satisfies the conditions of the case. It is, indeed, objected that the rigidity, and apparently unyielding nature, of ice—as seen in large masses—forbids our regarding it with correctness in the light of a semi-fluid, or viscous body. Hence Professor Tyndall, arguing on the facility with which ice, when fractured, becomes re-frozen by contact of its parts (especially when accompanied by pressure), proposes the theory of fracture and re-gelation, as accounting for the admitted movement of the glacier. But the plasticity, at least, of ice, seems proved by the very nature of the ice-stream, and its continuity of movement is more in accordance with the motion of running-water (though at an infinitely slower rate) than with that of a motion dependent on successive breakages and re-freezing.

2 Greek—isos, equal—thermé 'heat.'
degrees of heat, and, if such were the case, the parallels of latitude drawn upon our maps and globes would constitute isothermal lines. But this is by no means the case. On the contrary—and for reasons sufficiently explained in the preceding pages—places at correspondent distances from the equator exhibit, in numerous instances, widely different conditions of climate. Hence lines drawn through places of like temperature often deviate widely from the direction of parallels of latitude. This deviation, inconsiderable within the torrid zone, becomes greater with every further degree of advance in the direction of the poles. It is nowhere more widely marked than in the case of places lying upon opposite sides of the Atlantic Ocean, within the limits of the north temperate zone.

48. The western coasts of Europe have throughout a higher average temperature than the eastern coasts of the New World. Lines drawn through places of corresponding temperatures, in western Europe and the eastern seaboard of North America, range therefore some degrees nearer the pole in the case of the former than the latter of those localities. The mean yearly temperature of Lisbon (61°) in lat. 38° 42', is only four and a half degrees lower than that of Charleston, in South Carolina, which is six degrees nearer the equator. London, in lat. 51° 30', has a mean annual temperature of 50° 8', which is the same as that of Philadelphia, though the latter place is more than eleven degrees nearer the equator. Edinburgh, nearly under the 56th parallel, has a mean yearly temperature of 47, which is seven degrees higher than that of Halifax, in Nova Scotia, though the latter place lies upwards of ten degrees further to the southward. And Copenhagen, in lat. 55° 41', with a mean yearly temperature of 46° 5', is above eight degrees warmer than St. John, Newfoundland, though the latter place is more than eight degrees further removed from the pole. Numerous other instances might be quoted.

Plates which enjoy the same mean temperatures, taking the average of the entire year, often exhibit, however, widely different conditions of climate, even in respect of temperature only. In one case, the mean may be the result of a comparatively equal distribution of heat throughout the year—that is, of moderate summers, and correspondently mild winters; in the other, the same mean may result from excessive heat at the one season, balanced by extreme cold at the opposite period of the year—that is, from summers of excessive heat, and winters of extreme cold. Isothermal lines may of course be drawn through places of correspondent summer or winter temperatures. Such lines, which

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1 Isotherms of mean summer temperature are distinguished as *isothermal lines*—Greek, *isos*, equal; *theros*, summer; those of mean winter temperature, as *isochimenal lines* (isos, equal; *keima*, winter.)
are sometimes marked upon maps, exhibit in many cases a deviation from the direction of parallels which is even greater than that shown by isotherms of mean yearly heat. Similar lines indicative of the mean temperature for each month of the year are drawn upon the elaborate maps of Professor Dove, and exhibit the result of a vast number of observations, collected from upwards of eight hundred different stations, scattered at wide distances apart over the face of the globe.

49. A Map of the World upon which isotherms of mean yearly temperature are drawn illustrates strikingly the truth, that, within the temperate and frigid zones of the northern hemisphere, the western side of either continent is warmer by many degrees than its eastern side. The mean temperature both of the Old and New Worlds gradually diminishes with progressive advance to the eastward. Hence the isotherms, when prolonged round the entire circuit of the globe, within the zones referred to, assume in some parts a convex, and in others a concave shape. In other words, they rise to high latitudes upon the western coasts of Europe and North America, and, sinking in the direction of the equator as they traverse the eastern and western continents, reach their lowest points, where they respectively approach the eastern limits of Asia and North America. Pekin, the capital of China, has a mean temperature almost identical with that of New York, with which it nearly corresponds in latitude. And, similarly, the western seaboard of North America exhibits a degree of heat which resembles that enjoyed by the coasts of Western Europe under correspondent parallels of latitude.

50. The condition here stated with respect to the opposite shores of either continent applies, there is reason to believe, to the eastern and western of smaller areas of the land. The contrasted climates of Labrador and Western Greenland furnish an example. In Labrador the thermometer often falls in winter to $30^\circ$ and $40^\circ$ below zero, while the western coast of Greenland, many degrees farther north, exhibits no correspondent intensity of cold.

51. Furthermore, while the mean of yearly temperature is highest on the western side of either continent, and diminishes to the eastward, the extremes of seasonal temperature become more strongly marked with advance in the same direction. That is, the western coasts of Europe and North America enjoy comparatively moderate summers and mild winters, while the plains of interior and eastern Asia, in the Old World, with the Atlantic seaboards of North America, in the western hemisphere, experience summers of intense heat and winters of excessive cold. The summer of New York is hotter than
that of Algiers, and the winter colder than that of Copenhagen; Montreal has a summer nearly as warm as Lisbon, and a winter as cold as Petersburg; and Pekin possesses, in point of temperature, nearly the same summer as Cairo, with a winter as severe as that of Stockholm.

Examination Questions.

1. To what three principal causes are differences of climate due?
2. In what way do the differences in the respective lengths of day and night, at opposite seasons, affect the climate of places lying within the higher latitudes of the globe?
3. Say what are the characteristics, as to temperature, of the torrid, temperate, and frigid zones, respectively.
4. In what way does height above the sea affect climate? Say what is the general characteristic of plateau lands in respect of temperature.
5. What effect upon climate is generally produced by proximity to the sea? Give some examples in illustration.
6. What minor causes also tend to regulate climate?
7. Illustrate by some examples the influence of prevailing winds upon the climate of various regions.
8. Describe the nature of the winds respectively known by the names of simoom, tebbad, sirocco, föhn, harmattan, and mistral, and say where they are respectively experienced.
9. What three general rules serve to express the greater or less abundance of rainfall in particular regions?
10. Say what are the respective seasons of rainfall within the tropics, to the north and south of the equator.
11. Give some account of the monsoon-rains.
12. What portions of the globe fall within the so-called "rainless belt"?
13. What conditions regulate the height of the snow-line?
14. What are glaciers? Describe briefly the nature of their motion.
15. What are isothermal lines? In what do they differ from parallels of latitude?
16. What striking differences are found, on comparing the respective temperature of places upon opposite sides of the North Atlantic Ocean, in correspondent latitudes?

1 At Pekin, the thermometer in June and July sometimes reaches 100° Fahr., the average maximum being about 90°, while in winter it occasionally sinks to 6° below zero.
XI

AGENTS OF CHANGE.

1. The preceding chapters describe the natural aspect of the earth's surface, as it exists in the present day. But this condition undergoes continual change—in some cases, by stages so slow and gradual, and performed through agencies so little obvious to cursory observation, as to pass comparatively without notice; in others, by means of phenomena so violent, and attended with results so destructive and disastrous, as to constitute the most striking amongst the natural forces manifest in the external world. Such changes as are referred to may be classed, for the most part, under one or other of two great divisions—aqueous and igneous; according as they are due to the agency of water, or to that of fire.

2. Aqueous changes.—We must refer to the works of professed writers on geology—and, particularly, to Sir Charles Lyell's admirable "Principles of Geology"—for a complete account of the various ways in which water constitutes an agent in effecting natural changes in the aspect of the earth's surface, and especially in the relative contour of land and sea at their line of contact. Some of such changes constitute agents of destruction—others of reproduction. In the former, there is a tendency for the ceaseless action of water to destroy the land, of which the undermining and consequent falling of cliffs upon certain parts of the coast, in the case of nearly all maritime countries, or the inundation of extensive tracts of land, offer the most familiar examples. In the latter, the same agent—running water—operates to fill up estuaries and harbours, or to add to the extent of land by means of the formation, at the mouths of rivers, of those tracts of alluvial soil known as deltas.

3. The eastern shores of the North Sea, between the mouths of the rivers Scheldt and Elbe—including the coasts of Holland and the
neighbouring portions of Germany—offer some of the most prominent instances of destructive change, due to the violent action of the sea. The immense gulf known as the Zuyder Zee, which measures between 40 and 50 miles in either direction, and is, in the present day, the scene of no inconsiderable amount of Dutch enterprise, was formed by irruptions of the sea during the thirteenth century. A portion of its site was anciently occupied by Lake Flevo, a body of inland water fed by the inundation of the Rhine over the adjacent marshes. During successive periods of storm, the sea burst over the adjacent lands, forming several channels of communication with the inland waters, which were at length widened into the present broad entrance of this extensive but shallow basin.

4. The whole line of the Dutch coast presents the evidence of similar changes, and the islands which extend from the Helder to the mouths of the Weser and the Elbe, have undergone repeated alterations of form and size. Farther to seaward, the island of Heligoland (a British possession) has become reduced to a mere fragment of its former area: the deep-sea channel which now divides it from Sandy Island, to the eastward, was once dry land. The large gulfs known as the Dollart and the Jahde are of like origin to the Zuyder Zee. They owe their existence to inroads of the adjacent waters, and were progressively formed at various periods between the eleventh and the sixteenth centuries. The western coasts of Denmark have been similarly exposed to the ravages of the ocean. During a violent storm in 1825 the sea broke through the narrow isthmus by which the Liim Fiord (in the northern part of Jutland) was terminated to the westward, the waters of the North Sea thus forcing for themselves a communication with the channel of the Kattegat. The passage thus formed having become closed with sand, a canal was cut, but it can only be used by small vessels.

5. But the industrious Dutchman of modern times has successfully opposed his skill to the further ravages of the ocean, and has gained from its waters more than he has lost. Large tracts of land have been recovered from the sea by means of drainage. In some parts of the Netherlands the land is actually on a lower level than the adjacent waters, and is only preserved from inundation by means of artificial mounds or dykes. Elsewhere the required protection is supplied by the agency of natural means. From the channel of the Helder (the principal entrance to the Zuyder Zee) southward, the coast of the North Sea is protected by a broad line of
sandhills, or dunes, the features of which have been described in a preceding page.¹

6. There is reason to believe that the western coasts of France, in the neighbourhood of the Channel Islands, have undergone considerable change, with loss of land, within the historical period, while the islands themselves have become diminished, both in number and magnitude. Above twenty feet of water now cover, in some places, what was once dry land.

7. Changes on British Coasts.—The coasts of Britain exhibit, through the greater portions of their circuit, instances of change due to the action of tidal currents and waves. This change is sometimes attended by gain of land, but more frequently involves an opposite result, and the labours of the engineer are called into requisition for the purpose of checking the continual waste. Those portions of the English coast which lie between the high rock of Flamborough Head and the estuary of the Thames—embracing the low tract of Holderness, in the east riding of Yorkshire, with the coasts of Lincoln, Norfolk, Suffolk, and Essex—have been peculiarly the seat of such changes. The shores of Kent, Sussex, Hants, and Dorset, exhibit the action of like changes, in nearly equal degree. Throughout this extensive range of coast, the cliffs consist, for the most part, either of chalk, or of soft sands and clays, which yield readily to the erosive action of water. Nearer the entrance of the Channel, the cliffs of Devon and Cornwall, which are composed chiefly of harder rocks, decay less rapidly; though even here the hollow, water-worn recesses and caves, which are of frequent occurrence, show how powerful an action the ceaseless beating of the waves exerts upon the hardest materials. And the same thing is the case upon many parts of the iron-bound coast which forms the seaward barrier of a large portion of Britain to the westward.

8. The estuary of the Humber, including, upon either side, the lowlands of the Yorkshire and Lincolnshire coasts, is undergoing continual and important changes. The water of the Humber is exceedingly turbid, holding in suspension large quantities of earthy sediment (or

¹ History records a well-known occasion on which this peculiarity of physical conformation proved the means of salvation to the industrious citizens of the Low Countries. During the siege of Leyden, in 1573-4, when all other means of defence were exhausted, the Dutch broke down the neighbouring dykes, and thereby compelled the breaking-up of the besieging army, while a fleet of boats advanced across the inundated land to the walls of the city, and carried relief to its gallant defenders, then reduced to the actual verge of starvation.
"warp," as it is locally termed), which it deposits upon the flats on either side. The alluvial deposits thus formed extend several miles inland, and their level does not exceed that of the average rise of the tide. In some places, however, a continual waste of land is in progress, and serves as a compensation for the gain of solid ground along other portions of the estuary. While large tracts that were formerly occupied by the water have been reclaimed within a recent period, in other places the channel has become considerably widened.

9. Upon the coast of Norfolk and Suffolk, many villages, and even towns, have been gradually destroyed by the successive fall of large portions of cliffs, owing to the undermining action of the waves. The town of Cromer, upon the Norfolk coast, no longer occupies its former site, the inhabitants having been compelled to retire inland, as portions of the land have successively given way to the ravages of the sea. The entire site of the older Cromer now forms part of the bed of the German Ocean. The action of the sea is here aided by the agency of land-springs, by which large portions of the upper cliffs are frequently undermined. On the same coast, several well-known villages of former days have disappeared; manors and large portions of neighbouring parishes have been swallowed up, piece by piece; nor has there been any interruption, from time immemorial, in the ravages of the sea. Elsewhere, however, nature herself erects a barrier to these and similar ravages. Between Eccles and Winterton (on the same coast, to the south-eastward), hills of blown sand, or dunes, have barred up and excluded the tide from the mouths of several small estuaries, and similar hills of sand protect the coast between Happisburgh and Yarmouth. Farther south, on the coast of Suffolk, the village of Dunwich preserves the name of what was once a considerable city, the site of which has long been buried beneath the waters of the adjacent ocean. The destructive action of the sand, driven inland, in many localities, by the ceaseless agency of the wind blowing from seaward, has been noticed in a preceding chapter.

[Numerous other instances of like nature might be quoted, as well in reference to other parts of the world as in the case of our own shores. The sum total of such changes, considered even in reference to a single generation, is by no means inconsiderable, and when viewed in regard to periods of centuries in duration, they become yet more important.]

10. Influence of Rivers in producing Physical Changes. Rivers exert a highly destructive agency in the case of those violent floods, or débâcles, of which their valleys are the occasional seat. Such
phenomena are due to the extraordinary force of running water, accumulated in the upper portion of the valley, and afterwards suddenly impelled to burst the confining barrier, pouring a resistless flood through the lower portions of its basin. "The power," says Lyell, "which running water may exert, in the lapse of ages, in widening and deepening a valley, does not so much depend on the volume and velocity of the stream usually flowing in it, as on the number and magnitude of the obstructions which have, at different periods, opposed its passage. If a torrent, however small, be effectually dammed up, the size of the valley above the barrier, and its declivity below, and not the dimensions of the torrent, will determine the violence of the débâcle." Such barriers are sometimes temporarily formed, in the case of rivers which have their origin in high mountain-regions, by winter ice, the melting of which, with the returning spring, is productive of the most disastrous consequences.

11. River-Floods.—The violent flood which occurred, in the year 1818, in the valley of Bagnes, one of the small lateral branches of the Rhone valley, above the Lake of Geneva, has often been referred to. In this case, the upper portion of the torrent which flows through the valley had been converted into a lake, through the damming up of a narrow pass by avalanches of ice and snow, precipitated from an elevated glacier above. This ice-barrier remained entire until the melting of the snow in the spring, when, after half of its contents had been drained off by artificial means, the increasing heat of the weather occasioned the violent destruction of the entire barrier, and the whole remaining contents of the reservoir were at once poured into the valley below. Rocks, forests, houses, bridges, were swept along by the irresistible force of the flood, and, through the greater part of its course, the stream is described as resembling a moving mass of rock and mud, rather than water. The flood left behind, in the plain of Martigny, thousands of trees, torn up by the roots, together with ruins of numerous buildings. For months subsequently, the bed of the torrent continually shifted from one side of the valley to the other, without any fixed channel.

12. An instance of like kind, upon a scale of vastly greater magnitude, occurred in the valley of the river Indus, in the year 1841. The Indus has its origin amidst the glaciers that belong to the Himalaya mountain-region, but the middle and lower portions of its course are through a vast plain. During December 1840, and January 1841, the river, between Torbela and Attock, was observed to be unusually low; at length it was even fordable a short distance above Attock. In April and May it rose, and in June a deluge like an ocean came
tumbling and roaring down across the Indian plains, rolling out on either side, travelling with terrible velocity, and making its approach known by a sound like heavy thunder, or the discord of a battle. A stupendous glacier had been formed in the valley of Khundan, and the accumulated drainage of the vast area of the mountain-region had gathered above the obstacle. The ice was like a new mountain, suddenly flung as a barrier across the channel. It was a mile in thickness. Gradually, however, the heat of the earth beneath, and of the sun above, wore hollows in the frozen mass; the entire glacier at length gave way, and the aggregated waters, sufficient to fill a lake of twelve miles in length, half a mile in breadth, and two hundred feet deep, were poured into the valley. Houses and trees, herds and flocks, men and women, were swept away together, and large alluvial tracts stripped of their soil. Opposite the fort of Atock, eight hundred miles distant from the Khundan valley, the inundation rushed in one towering wave, breaking over the tops of trees, and rolled on, as sublime as irresistible, until it met the tide of the Indian Ocean, after a career of seventeen hundred miles! "The devastating effects of this terrible flood," says Major Cunningham, "were still quite fresh in 1847. At Tertse, one of the widest parts of the valley, they could be traced to a height of more than twenty feet above the stream, where straws and twigs were massed together in lines two or three feet broad, and upwards of half a mile from the channel of the river. But the most striking effect of the flood was the entire absence of trees in the valley of the Shayok, while the lateral valley of Nubra was full of trees upwards of a hundred years old. . . . The shepherds and herdsmen, with their flocks and herds, were overwhelmed in the midst of the open plain, without a chance of escape." . . . "At Torbela," says an eye-witness, "about 2 P.M., a murmuring sound was heard from the north-east among the mountains, which increased until it attracted universal attention, and we began to exclaim, 'What is this murmur? Is it the sound of cannon in the distance? Is Gandgarh bellowing? Is it thunder?' Suddenly some one cried out, 'The river's come!' And I looked, and perceived that all the dry channels were already filled, and that the river was racing down furiously in an absolute wall of mud; for it had not at all the colour or appearance of water. They who saw it in time easily escaped. They who did not, were inevitably lost." . . . Throughout the mountain-course of the river, the devastation caused by this terrible flood in the lowlands along the banks of the stream was complete. All the cultivated lands were swept away, and not even a single tree was left standing to mark the spot where careful tillage and laborious irrigation had for hundreds of years wrung luxuriant crops from the thirsty soil.

13. Land-slips.—Catastrophes such as the above are by no means the only form of change due to the agency of running water. The land-slips which are of more or less frequent occurrence in all hilly regions are mainly due to the same cause—the influence of water penetrating through subterranean fissures and channels, and, by ceaseless erosion, wearing away the base upon which the superjacent strata rest, until whole masses of the hill-side are put in motion,
descending, with all that rests upon their surface, to a lower level. In other cases, the flood tears away whole masses of land from the bank of a running stream.

14. Land-slips of this latter kind occur on a scale of great magnitude on the banks of the Solimoes or Upper Amazons. "Large vessels," says Mr. Bates, "are sometimes overwhelmed by these avalanches of earth and trees. I should have thought the accounts of them exaggerated if I had not had an opportunity during the voyage of seeing one on a large scale. One morning I was awoke before sunrise by an unusual sound resembling the roar of artillery. I was lying alone on the top of the cabin; it was very dark, and all my companions were asleep, so I lay listening. The sounds came from a considerable distance, and the crash which had aroused me was succeeded by others much less formidable. The first explanation which occurred to me was, that it was an earthquake; for although the night was breathlessly calm, the broad river was much agitated, and the vessel rolled heavily. Soon after, another loud explosion took place, apparently much nearer than the former one; then followed others. The thundering peal rolled backwards and forwards, now seeming close at hand; now far off; the sudden crashes being often succeeded by a pause or a long continued dull rumbling. . . . The day dawned after the uproar had lasted about an hour, and we then saw the work of destruction going forward on the other side of the river, about three miles off. Large masses of forest, including trees of colossal size, probably 200 feet in height, were rocking to and fro, and falling headlong one after the other into the water. After each avalanche the wave which it caused returned on the crumbly bank with tremendous force, and caused the fall of other masses by undermining them. The line of coast over which the land-slip extended was a mile or two in length; the end of it, however, was hid from our view by an intervening island. It was a grand sight: each downfall created a cloud of spray; the concussion in one place causing other masses to give way a long distance from it, and thus the crashes continued, swaying to and fro, with little prospect of a termination. When we glided out of sight, two hours after sunrise, the destruction was still going on."

15. Deltas.—Reference has been made to deltas in a preceding page. They consist of alluvial soil, the material of which has been brought down by a stream from the higher portions of its course, more particularly during those seasons of flood to which all rivers that derive their waters from mountainous districts are more or less liable. There is a constant tendency for such sedimentary matter to be deposited in the bed of the stream; and this tendency is greatly increased at the embouchure of the river, where its waters meet the sea, especially if there be any local current preserving a direction at right angles to that of the stream itself. Hence the formation, and frequent shifting, of sand and mud banks in the beds of rivers; and hence also the bars which are so often formed at their mouths.

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The Naturalist on the Amazon. (London.)
16. It is only where, owing to local conformation of the surface of the ground, the main channel of a river divides into two or more branches, that a delta is formed. In such cases, the continual deposit of alluvial matter tends to increase the extent of the delta—the newly-formed soil gradually advancing itself further out into the sea. The gain of land thus occasioned is in some cases considerable, though much less in amount than (at least in the existence of some well-known deltas) has frequently been suggested. The rounded shape—convex towards the sea—which many deltas (as those of the Nile, the Po, the Rhone, the Ganges, and other streams) exhibit in their contour, results from the continual growth of land within the space enclosed between the outer arms or channels.

17. The mouths of the Po and Adige furnish one of the most striking examples of growth of land due to the agencies here referred to. The waters of both these streams are abundantly charged with the sediment which their numerous feeders, swollen with every succeeding spring by the melting of the winter snows, bring down from the Alps and Apennines. The continual deposit of this matter towards the lower portion of its channel has, in the course of ages, raised the bed of the Po above the level of the adjacent plains, so that it requires to be confined between artificial embankments upon either side; and the same cause has tended to a continual growth of alluvial soil along the Adriatic coast, where the river meets the sea. Within the last two thousand years, this growth of land has amounted in some places to a breadth of twenty miles; and throughout a line of coast measuring a hundred miles in length, the growth of land varies from two to twenty miles. The town of Adria, which was a seaport in the time of the Romans, is now nearly twenty miles inland. The delta of the Rhone presents a like example of growth, though less rapid.

18. Both the Ganges and the Indus exhibit instances of considerable and constant growth of land at their outlets, as well as of frequent changes in their channels. So great is the quantity of mud and sand annually poured by the Ganges into the Bay of Bengal in the season of flood, that the sea only recovers its transparency at the distance of sixty miles from the coast. The main channel by which the waters of the Brahmaputra river (the arms of which unite with those of the Ganges at their outlet, and form with it a joint delta of many thousand square miles in area) reach the sea has altogether shifted its place within a recent period. The delta of the Mississippi furnishes a like example in the New World. The tongue of land now projects far out, beyond the general line of coast, into the waters of the Mexican Gulf, and has advanced many leagues since the city of New Orleans was built.

19. Igneous Causes of Change.—The phenomena due to the agency of the earth’s internal heat make themselves manifest, at least

1 Latin, alluvium, I wash upon. "The term alluvium" (of which alluvial is the adjective form) "comprehends," says Lyell, "earth, sand, gravel, stones, and other transported matter which has been washed away and thrown down by rivers, floods, or other causes, upon land not permanently submerged beneath the waters of lakes or seas."
for the most part, by sudden and violent action, frequently attended by catastrophes of the most disastrous description. The earthquake and the volcanic eruption have been, in all ages, among the most fruitful causes of disaster incident to the works of nature, and have been repeatedly attended by loss of life, and other suffering to the human race, to an amount which it is frightful to contemplate.

20. The earthquake and the volcanic eruption may, with the highest probability, be regarded as allied phenomena, and as exhibiting the action of the earth’s internal heat upon the outer surface of the globe. The proximate cause of earthquakes is probably to be found in the chemical changes which result from the mutual action of various substances composing the crust of the earth, and which changes are connected with development of heat through the hidden agency of electricity. But the intense force manifested in such phenomena, not less than certain conditions which accompany their recurrence in particular districts, points to some more deeply-seated and general cause; and there can hardly be a doubt that this is found in the heated condition of the earth’s interior. That subterranean heat exists in every part of the earth—warm and cold regions alike—is a well known fact: experiments made in widely-distant localities show a nearly uniform rise of temperature from the surface of the ground downwards, the ratio of increase being in the proportion of one degree of Fahrenheit’s thermometer for about every sixty or seventy feet of perpendicular descent.¹

[It is true that the greatest depths to which the operations of man have penetrated affect no more than a thin pellicle of the earth’s crust, the deepest mines scarcely exceeding two thousand feet. Nor are we entitled to assume a continued rise of temperature in the same ratio for considerably greater depths, since the continually increasing pressure, as well as the varying conducting power possessed by the different strata, requires to be taken into account. It is, however, impossible to resist the general conclusion—the connection, namely, of increased heat with increased depth—to which all such observations point. The rise of temperature here adverted to would not be found of such wide and uniform distribution were it not due to some general cause. The wide-spread occurrence of hot springs, again, is evidence of the heating agencies which exist at considerable depths below the earth’s surface. The manifestation of these

¹ The heat which exists below the superficial covering of the globe is nowhere more strikingly manifested than in the case of such regions as Siberia, or the Arctic latitudes of North America, where, owing to intense severity of climate, the subsoil remains permanently frozen at the depth of a few feet—the heat of the short Arctic summer only thawing the ground to a trifling distance below the surface. But this frozen subsoil is itself only a stratum of limited thickness, on penetrating below which the temperature again rises, the increase of heat here, as elsewhere, bearing a direct ratio to the depth.
heating agencies is probably connected with local conditions of natural formation which are beyond the reach of man's direct observation, as well as with chemical and electrical forces. The elastic gases contained in cavernous reservoirs beneath the ground tend, under the influence of heat, to burst the covering within which they are confined, and produce, by the force which they exert, an upheaval or disruption of the solid crust of the globe—that is, an earthquake.]

21. Earthquakes.—It appears, from the accurate records of such phenomena which have been kept within recent periods, that earthquakes are of much more frequent occurrence than is commonly supposed. Upwards of three thousand earthquakes are recorded as having occurred within the first half of the present century—an average of more than one for every week throughout the entire period. But not more than one in forty is of considerable importance, by far the greater number consisting of such slight shocks as are occasionally experienced in Great Britain and other countries favoured with a like immunity in this regard. An important earthquake, however, in some part of the world or other, appears, from the above average, to occur once in every eight months. In Europe alone, where a more complete record of such occurrences is obtainable than in other parts of the world, as many as 320 distinct earthquakes are recorded to have occurred within a period of ten years (1833-1842)—an average of thirty-two annually, and of one such shock for every ten days throughout the period.

[The geographical area within which shocks of earthquakes are experienced is a widely-spread one, and does not appear to undergo any material change (if, indeed, any change whatever) as to its limits. At any rate, the regions in which violent earthquakes are recorded to have occurred in former times are those in which such disturbances are of most frequent recurrence at the present day. One of the most striking evidences in favour of the supposition that the volcanic eruption is due to the same deeply-seated cause which produces the shock of the earthquake, is afforded by the fact, that all the volcanoes which have been in eruption within the modern period of geology are found within regions liable to earthquakes, and, for the most part, to violent shocks.]

22. Volcanic Circuit of the Pacific.—Regarding the earthquake and the volcanic eruption as the manifestation, under different conditions, of the earth's internal fires, we readily mark out upon the globe the great regions of geographical distribution in the case of such phenomena. The most widely-extended of these coincides with the circuit of the Pacific Ocean. Along the entire western coast of the New World, from Tierra del Fuego to the peninsula of Alaska and the neighbourhood of the Aleutian Islands, shocks of earthquakes are known to occur; and, within a large portion of the space, vents of
active eruption are found. The subterranean igneous force is, indeed, much more powerfully displayed in the southern than in the northern half of the American continent, and the active volcanoes that occur within the limits referred to are nearly all found amidst the cordilleras of the Andes, or upon the plateaus of the Mexican isthmus. Chili, Peru, and the western portions of Columbia—in fact, the whole range of country lying along the west coast of South America—have frequently experienced shocks of earthquake of the most violent description, many of them so considerable as to occasion great and permanent changes in the level of the ground, and a few days (at most, a week or two) rarely pass without some minor indications of the force which is at work beneath. In the Patagonian Andes, the most southward portion of the great mountain-system, four active volcanoes occur between the parallels of 44° and 42° S.; and of the Chilian Andes, no fewer than nineteen are active volcanoes. The Andes of Bolivia and Peru contain fewer points of eruption, and between the parallels of 30° and 23° no active volcanoes occur; amongst the double chain of the Colombian Andes, in the immediate neighbourhood of the equator, numerous volcanoes are again found. Amongst them, within the province of Quito, and nearly under the line of the equator, is Cotopaxi, upwards of 18,000 feet in altitude, and the highest of the volcanoes that has been in a powerfully active condition within the modern period. Upon the western side of Central America, again, active volcanoes line the shores of the Pacific; further to the northward, several insulated volcanic peaks rise above the Mexican table-land. One of the Mexican volcanoes—Jorullo—is especially deserving of notice, from the circumstances of its having first risen above the surrounding plain by the accumulation of volcanic matter during an eruption in the year 1759.

23. The Aleutian Islands connect the volcanic region of the eastern Pacific with that which extends along its western shores. In the latter case, however, it is upon the peninsula regions, or in the chains of islands that adjoin the mainland, that the igneous force is displayed. Kamtchatka, the Kurile Islands, Jesso, the Japanese group, and the entire region of the Malay Archipelago, exhibit the presence of igneous force below the ground. Seven active volcanoes occur in Kamtchatka. The Japanese Archipelago is said to contain at least twenty-seven active volcanoes, eight of them upon Jesso and the adjacent islets.1 Between Japan and the Loo-choo group is

1 Forbs, in Proceedings of Royal Geographical Society, vol. x.
Sulphur Island, an insular volcano, from which smoke is constantly emitted.

24. The Philippine Islands, in which earthquakes are of frequent occurrence, prolong the volcanic chain to the southward. Thence it is traced, at intervals, along the northern shores of New Guinea, and through the prolonged chains of the Solomon Islands, and the New Hebrides, to the North Island of New Zealand. Slight shocks of earthquake have also been experienced within the southern and eastwardly portions of the Australian mainland. Perhaps the lofty cone of Mount Erebus (South Victoria), which was found by Sir James Ross sending forth its fires at a height of more than 12,000 feet, and within 12° of the southern pole, should be regarded as a more distant extension of the same volcanic chain, which may thus be looked on as completely girdling the Pacific basin. The detached volcanoes of the Friendly, Society, and Marquesas groups, in the South Pacific, with those of the Sandwich Islands in the northern half of the great ocean, are outlying points of the same volcanic region.

25. Volcanic System of the Indian Ocean.—The numerous volcanoes of the Malay Archipelago, the whole area of which is liable to frequent earthquake shocks, often of the most destructive violence, belong to the eastern portion of this region, and display the agency of subterranean heat on the grandest scale. The island of Java alone contains forty-three active volcanoes, ranging in a linear direction throughout its length. The volcanic chain of Java is prolonged to the eastward through the Lesser Sunda Islands (Sumbawa, &c.), in which direction it is united with that which borders the Pacific waters.

There are active volcanoes on an island in the Gulf of Siam, besides the well-known crater of Barren Island, in the Bay of Bengal. The region adjoining the last-named body of water, together with the whole of Northern India, is of frequent liability to earthquakes, some of them (as that of Cutch, in 1819) of the most destructive violence. The volcanic island of Mayotta (Comoro group), the active Piton of Ré-union or Bourbon Island, and the hot springs and extinct craters of St. Paul and Amsterdam Islands, in a high southern latitude of the Indian Ocean, constitute points which indicate, at distant intervals, the continuity of the volcanic chain.

26. The Volcanic System of the Atlantic.—The south-western portion of Asia, the southern shores of Europe, and the north-westwardly portion of the African mainland, fall within this region on the
one side, as the islands of the West Indies do upon the other. The entire breadth of the Atlantic Ocean, as well as the circuit of the Mediterranean, is thus included within its limits. To the northward, the numerous volcanoes of Iceland, and the more distant cone of Jan Mayen Island, lying within the Arctic circle, must be regarded as within its area; together with, in an opposite direction, the still-burning peak of the Camaroons Mountain, adjoining the upper extremity of the Gulf of Guinea. The volcanic peaks found within the widely-detached groups of the Azores and the Cape Verde Islands, with Teneriffe, in the Canary group, are amongst its outlying members.

27. Throughout the wide region thus indicated, earthquakes are of frequent occurrence. There are fewer active vents of eruption than in the case of the Pacific circuit. But the cones of Etna and Vesuvius, with the island of Santorin, in the Mediterranean, and the numerous volcanoes of Iceland, attest the destructive violence of the subterranean fires. Western Asia, from the Caspian to the shores of the Archipelago (including Armenia, Syria, and the Lesser Asia), Greece, Southern Italy, the Spanish peninsula, and the region of Mount Atlas, in North-western Africa, are all liable to the frequent repetition of such convulsions. The only portion of the Mediterranean coasts exempt from such disturbing phenomena is on its southern shores, embracing that part of the North-African coast which stretches from the Lesser Syrtis to the valley of the Nile. We have no record of the experience of any shocks of earthquake in Egypt. Had it been otherwise, perhaps the pyramids of that land of wonders might have proved less enduring monuments of the past.

[It was formerly reported that in the interior of the Asiatic continent there was a region of volcanic disturbance further removed from either of the great oceanic basins than is elsewhere found. Recent observations have, however, shown that of active volcanic phenomena nothing is seen in Central Asia at the present day. Over the greater part of the Indian peninsula, particularly on the northern side of the valley of the Ganges, and in the tract adjacent to the Lower Indus, earthquakes are experienced, as well as in the region which stretches between the western portion of the Himalaya and the valley of the Oxus. In the western part of the Arabian peninsula, and upon the Abyssinian plateau, upon either side of the Red Sea, similar phenomena are experienced. The lower portion of the Mississippi valley, and some parts of the country bordering on the river and gulf of St. Lawrence, are also subject to the occasional occurrence of such shocks, though with a modified degree of intensity.]

28. Nature of Earthquake-shocks.—The movement imparted to the ground during an earthquake may be either horizontal or
vertical. In the former case, the phenomenon consists in an undulating, wave-like movement; in the latter, in an upheaval or subsidence of land. The vertical shock affects most the relative levels of adjacent objects, and produces the most striking permanent changes in the natural aspect of the region in which it is experienced. But the undulatory movement is attended by more serious consequences to man, since it at once shakes the foundations of the strongest edifices, and may overthrow in the space of a few seconds the accumulated labours of prior ages. Whole tracts of land, with their cities or villages, may be elevated or depressed with comparatively little injury to life; but nothing can withstand the force of a motion which rocks the solid strata of the earth itself. The most solidly-constructed buildings are not proof against the earthquake any more than the weakest. Indeed, it has in many instances been observed that those erections which displayed the strongest masonry have suffered more from the effects of an earthquake than buildings of slighter structure. The cracking of walls, the falling-in of roofs, and the crash of tumbling houses on every side, burying their inmates beneath the ruins, are among the characteristics of the earthquake in its most violent and frightful form.

29. It has been asserted that a third kind of movement—viz., in a rotatory direction—sometimes occurs, and certain phenomena by which earthquakes have been attended have favoured this belief. Thus, isolated columns or statues have been found, after such an occurrence, to face a different quarter from that which they previously did. This, however, would be sufficiently accounted for by a vibratory movement, acting upon a column which was unequally attached to its base—that is, the fastening of which was of unequal strength relatively to the central point of junction. During the Chilian earthquake of 1835, vessels moored alongside of one another in the harbour of Conception were afterwards found with their cables twisted together.

30. The duration of any single earthquake shock is seldom more than a few seconds, though the terror which it inspires naturally tends to make it seem of longer continuance; but in the case of the more violent movements, even a few moments serve to destroy the work of ages. In the Chilian earthquake of 1835, the great shock which destroyed the city of Conception was preceded by several tremulous movements of minor intensity. During the first half minute, many persons remained in their houses; but the convulsive
motion of the earth then became so strong that all rushed into the open streets for safety. The horrid motion (writes an eye-witness of the scene) increased; people could hardly stand; buildings waved and tottered; suddenly an awful and overpowering shock caused universal destruction. In less than six seconds the city was in ruins!

31. The earthquake is propagated to enormous distances from the region in which the shock originates, the rate at which the motion travels varying not merely with the violence of the originating impulse, but also with the nature of the formations through which it passes. Rocks of solid and homogeneous texture, as granite, favour the transmission of the shock; while formations of loose texture, such as sand, most retard its speed. The well-known Lisbon earthquake of 1755, by which sixty thousand persons are said to have perished within the brief space of six minutes, was felt in the British Islands, as well as upon the coast of Barbary, and even among the islands of the West Indies, on the opposite side of the Atlantic.¹

[The southern portion of Italy constitutes one of the regions in which earthquakes have occurred with the greatest frequency in modern times, and in which the disastrous consequences that often attend on such catastrophes have been experienced in the fullest extent. Within scarcely more than the last three quarters of a century, as many as six great earthquakes, not reckoning minor shocks, have laid waste extensive tracts of that beautiful, and, in other regards, highly-favoured region, causing great loss of human life, as well as in various ways the most frightful suffering and distress. The first of these was the often-described Calabrian earthquake of 1783-6. This commenced on February 5th with a violent shock, which in less than two minutes levelled to the ground more than a hundred towns and villages, and buried 32,000 of their inhabitants under the ruins. Other shocks succeeded, and by the beginning of 1784, Calabria had already lost more than 80,000 of its inhabitants. Between the months of February and December, 1783, there were not fewer than 949 shocks; 151 shocks occurred during the succeeding year, nor did they altogether cease until 1786. The changes consequent upon this lengthened period of disaster were of the most striking description. Mountains were cleft asunder, high cliffs tumbled down, rivers turned from their beds or dammed up in their courses, lakes formed, valleys elevated into hills, deep chasms opened, the physical aspect of the country changed, the landmarks of property removed, and the relations of society in great measure disorganised.

The second of the catastrophes above referred to, in connexion with this devoted region, occurred in 1804, when the province of Molise was the centre of a violent earthquake, which lasted 35 seconds, and caused great desolation over an

¹ The shock travelled to Corunna at the rate of 1994 feet per second; to Cork, at the rate of 5280 feet; and to Santa Cruz, in Barbary, at the rate of 3261 feet.
area of six hundred square miles, involving the destruction of 61 towns and villages, with a loss of 6,000 lives. The third took place in 1835, when the town of Cosenza, and a large adjoining tract of country in the province of Calabria Citra, suffered severely. The neighbouring province of Basilicata was in 1836 the scene of a violent convulsion, and again experienced, fifteen years later (1851), a succession of destructive shocks, of which the town of Melfi was the focus. Last in order of enumeration comes the earthquake of 1857-8, of greater violence, and more destructive in its results, than any experienced within the same region since 1783. The first shock was experienced on December 16th, 1857, and during the two succeeding months a slight shock was felt almost periodically just before sunrise; nor did they altogether cease for some considerable subsequent period. The seat of this convulsion was in the central group of mountains in the provinces of Basilicata and Principato Citra, a part of the southward prolongation of the Apennine chain. Within an area of about 216 square miles, over which the more violent action extended, more than 12,000 persons (above a third of the resident population) were in less than half a minute crushed to death, and 2,000 severely wounded. The ground was cracked and convulsed in the strangest manner; chasms and deep fissures were opened in several places, fertile hills became bare rocks, valleys were raised up, small pools formed, and mountains cleft by deep ravines. The destructive effects of the earthquake extended, with slightly diminished intensity, over a much wider area, embracing upwards of three thousand square miles, and even reached, in a mitigated form, over the whole mainland of Southern Italy, from the extremity of Calabria as far northward as the town of Terracina, on the border of the Papal States, and Vasto (lat. 42° 8'), on the coast of the Adriatic—a distance of three hundred miles in direct lineal measure. A vast number of towns, within these wide limits, sustained more or less injury. On the whole, at least 22,000 human beings, on the most moderate calculation, were destroyed within a few seconds by this terrific earthquake.]

32. Volcanic Eruptions.—The most obvious characteristic of a volcanic mountain, when not actually burning, whether its fires be extinct or merely dormant, is its shape. The volcano is always of a form more or less conical, with the apex or point of the cone truncated, and, in its place, a hollow or depression towards the heart of the mountain—the well-known crater.¹ Besides the principal crater there are, in the cases of some volcanoes, numerous minor cones of eruption, from which the central fire has made its force manifest at different periods. Thus no fewer than eighty minor cones, each with its separate crater, are irregularly scattered around the sides of Etna.

33. When its fires have been dormant for any lengthened period, the volcano may exhibit, in the aspect of its crater, nothing calculated to disturb the idea of profound calm and repose. In the early part of the seventeenth century, when there had been no violent eruption

¹ Latin—crater, a cup.
of Vesuvius for a period of nearly five centuries, the appearance of
the mountain is thus described: — "The crater was five miles in circum-
ference, and about a thousand paces deep; its sides were covered with
brushwood, and at the bottom there was a plain upon which cattle
grazed. In the woody parts wild boars frequently harboured. In
one part of the plain, covered with ashes, were three small pools;
one filled with hot and bitter water, another saltier than the sea, and
a third hot but tasteless." But in 1631, this state of repose was
violently interrupted; the grassy plain and wooded sides of the crater
were blown into the air, and the volcano again exhibited itself as a
duct of connection between the heated interior of the earth and its
external surface.

34. The general direction of the strata of which the mountain is
composed, dipping from the centre outwards—a natural consequence
of the accumulated showers of ashes and other ejected matter—is
another indication of volcanic agency in its formation. But besides
these marks, and more unvarying than either, is the information
conveyed to the geologist by the structure of the rock, which, in the
case of a volcano, (whether of ancient or modern date), always
possesses a vitreous aspect and fracture, exhibiting a tendency towards
crystalline arrangement of its particles. This alone would determine
the volcanic character of the mountain, even though all traces of a
crater were lost, and the form was entirely different from what it
ordinarily is. Where streams of lava have flowed from the crater,
their position relatively to other beds of rocks, aided by an
examination of the fossils which the latter contain, determines the
respective ages of their issue. Thus the lavas of Ischia (an island on
the northern side of the Bay of Naples) must have flowed since the
period when the waters of the Mediterranean first became peopled
with their present forms of life; because in the beds of rock
interstratified among them, there are found numerous species of
testacea identical with those now existing in the adjacent sea.
Yet no signs of volcanic activity have been experienced in Ischia for
the last five centuries; and previous to the year 1302 (when a violent
eruption occurred) it is believed to have been at rest for a lengthened
period. Its fires are dormant, but they belong to the modern period;
and the island must be included within the volcanic region lying
around Naples, and claiming Vesuvius as its prominent feature.

[Extinct volcanoes must be distinguished from those that are in an active
condition, or of which the fires are merely slumbering. In the case of the former,

the geological evidence proves that neither lava nor any other matter has issued from them during the whole of the modern period, or that within which the earth has been inhabited by its present forms of life, vegetable or animal. Yet they may present a perfect analogy to the seats of modern volcanic fire, in so far as external appearance is concerned. There are many hundreds of such mountains in the district of Auvergne, in central France, each with its proper crater, a perfect volcano in form, and with abundant evidence of activity at a long-distant epoch. But this and similar regions of ancient volcanic force have no connexion with the areas of present subterranean fire.

35. Number of active Volcanoes.—Nearly three hundred active volcanoes are known, above two-thirds of the number being found in close proximity to the Pacific Ocean. In no other region of corresponding extent are there so many as in the island of Java. The list is of course subject to increase by any first display of volcanic force in the case of mountains which have hitherto given no outward indication of their contained fires. In the case of some volcanoes, the potency of the subterranean fire seems to be gradually diminishing, and its effects are limited to the issue of sulphurous and other gases, continually emitted from the crater. A volcanic mountain in this condition is called a solfatara,—a name derived from that of a nearly-extinguished crater, near Puzzuoli, on the shore of the Bay of Naples.¹ Teneriffe and others of the Canary Islands, with Stromboli, in the Lipari group, some of the volcanic islands in the Greek archipelago, and the Camaroons Mountain, in Western Africa, are in the condition of solfataras.

The following list includes a few of the principal active volcanoes in either hemisphere, with their elevations:

<table>
<thead>
<tr>
<th>WESTERN HEMISPHERE</th>
<th>EASTERN HEMISPHERE</th>
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<tbody>
<tr>
<td>Gualatieria (Andes)</td>
<td>Kliuchevsk (Kamtehatka)</td>
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<tr>
<td>Arequipa (do.)</td>
<td>Camaroons, Peak of (West Africa)</td>
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<tr>
<td>Antisana (do.)</td>
<td>Slamet (Java)</td>
</tr>
<tr>
<td>Cotopaxi (do.)</td>
<td>Indrapura (Sumatra)</td>
</tr>
<tr>
<td>Tolima (do.)</td>
<td>Tomboro (Sumbawa Island)</td>
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<tr>
<td>Popocatepetl (Mexico)</td>
<td>Teneriffe (Canary Islands)</td>
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<tr>
<td>Orizaba (do.)</td>
<td>Fusi Yama (Niphon: Japan)</td>
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<tr>
<td>Tunguragua (Andes)</td>
<td>Etna (Sicily)</td>
</tr>
<tr>
<td>Toluca (Mexico)</td>
<td>Piton de la Fournaise (Réunion)</td>
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<td>Mauna Loa (Sandwich Islands)</td>
<td>Beerenberg (Jan Mayen Island)</td>
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<tr>
<td>Erebos (S. Victoria)</td>
<td>Hekla (Iceland)</td>
</tr>
<tr>
<td>Cosiguina (Central America)</td>
<td>Vesuvius (Italy)</td>
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The gases given out by volcanoes are muriatic acid, sulphur combined with oxygen or hydrogen, carbonic acid, and nitrogen; together with immense quan-

¹ An instance (like the case of the word “delta”) of the extension of a geographical term from a special to a general sense. The solfatara near Puzzuoli appears to have been in nearly the same state before the Christian era as at the present time, giving vent only to aqueous vapours, with sulphurous and other gases.
ties of aqueous vapour. There is besides, a variety of ejected matter, among which are comprised ashes (often in dense showers), with stones, masses of rock, and various substances comprehended under the term "scoria," and, in many cases, streams of lava. The aqueous and gaseous vapours produce that appearance of smoke which generally heralds an eruption, and the semblance of flame by which it is accompanied proceeds, in most cases, from the clouds of red-hot ashes, aided by reflection (from the dense masses of vapour) of the glowing light emitted by the lava in the interior of the crater, which is literally a sea of liquid fire. In some instances, however, the seeming flames may be produced by inflammable gases in a state of actual ignition.

36. Violence of Eruptive Force.—The amazing force with which the ejected matter issues from a volcano, and the vast distances to which it is thrown, show how powerful is the cause to which volcanic phenomena are due, and point to some deep-seated origin, of a nature analogous to the forces operating in the general structure and movements of the natural world. The ashes ejected from Tomboro (in the island of Sumbawa, one of the Lesser Sunda chain), in the eruption of 1815, were carried on the side of Java to a distance of three hundred miles, and upwards of two hundred towards Celebes, in the opposite direction, in sufficient quantity to darken the air. The sound of the accompanying explosions was heard in Sumatra, at a direct distance of 970 geographical miles, and the cinders floating in the sea to the westward of that island formed a mass of two feet in thickness, and of many miles in extent.¹

¹ This eruption was one of the most frightful on record. But the most stupendous of our times was the volcanic eruption in 1883 of Krakatan, an island in the Sunda Straits, midway between Java and Sumatra. Vide Proceedings of the Royal Geographical Society, March, 1884.
ashy dust; and amongst the pieces of light pumice stone which covered the waters of the gulf were seen the bodies of countless inhabitants of the sea, of all sizes, from the smallest molluses and crustaceæ to the huge carcases of sharks and crocodiles, who appear to have been killed by the high temperature communicated to the sea by the glowing masses of scoria that fell into it. Dead fish were found in great numbers on the surface of Lake Managua, ninety miles off, and the water was entirely covered with ashes.

"The distances," (says Dr. Scherzer, in his "Travels in the Free States of Central America") "at which the thunder of this eruption was heard would appear quite incredible were not the fact confirmed by so many witnesses. In the capital of Guatemala, 240 miles in a straight line from Cosiguina, the concussion of the air was such as to make the windows shake at every detonation; and in the British colony of Belize, 300 miles off, the supposed artillery was loud enough to induce the English governor to order out the garrison. He imagined that there was a sea-fight going on in the neighbourhood, as the atmosphere was too clear for him to attribute the sound to thunder. In the opposite direction, the circle of detonation is stated to have extended southward to New Granada and Quito, close to the equator, and part of the ejected matter was still more widely diffused. Not only in all parts of Central America, but even in the highlands of Mexico, in Vera Cruz, Cuba, and Jamaica, ashes were seen to fall from the sky, and the astonished people could not for a long time discover the cause of the puzzling phenomenon."

37. Rivers and currents aid in the distribution of the matter ejected by volcanic agency. Pieces of pumice-stone that have been thrown out by the volcanoes of the Andes are found floating on the Amazons, at distances of more than a thousand miles from the mountain-region, and are no doubt often carried out by the current of the stream into the ocean, to be deposited, perhaps, thousands of miles away.

38. Lava.—Lava is unquestionably the most important of volcanic products, but its occurrence during an eruption is by no means uniform. No lava issues from the volcanoes of the Andes, though streams of it have flowed from some of the volcanic cones that rise above the Mexican plateau. Immense quantities of lava have repeatedly issued from the Icelandic volcanoes. Even in the case of Vesuvius, and other lava-emitting volcanoes, the ejection of lava is not an uniform accompaniment of the eruption. No lava issued from Vesuvius during the terrible eruption, the first on record, of A.D. 79, when Pompeii and Herculaneum were destroyed. These cities were buried beneath the shower of ashes ejected from the crater of the mountain. The excavations of modern times have restored Pompeii to the light of day, after the lapse of seventeen centuries.

39. When first issuing from the mountain, the lava flows in a smooth but rapid torrent, in regular channels, and in a perfect state
of fusion. But as it advances, and its stream widens, it speedily loses this smoothness of aspect, becoming a dense, viscous, and semi-fluid substance, easily deflected from its course by irregularities in the surface of the ground, and travelling onwards with a slow and steady motion. Bodies of even considerable weight, as stones weighing ten or fifteen pounds, make little or no impression on the surface of the stream, but larger masses of rock become slowly and gradually absorbed in it. The front and sides of the lava-torrent present well-defined lines; their immediate contact with the atmosphere causes them to cool sooner than the central parts of the stream, and to consolidate earlier, while the more liquid portions flow over their hardening mass,—particular parts thus becoming heaped up in rocky waves. The entire body of the lava contracts as it parts slowly with its heat, and opens in numerous cracks and fissures, so that the tract over which a lava-stream has flowed exhibits subsequently a broken, rugged, and blackened aspect, irregular masses of the lava rock being mixed with heaps of cinders and other volcanic substances. But atmospheric influences gradually soften the more prominent features of the scene, and the disintegrated lava-torrent often becomes, in process of time, converted into a soil of more than ordinary fertility.

40. Composition of Lava.—The mineral composition of lavas is various, and according as different elements prevail in their composition, they are termed trachytic, basaltic, or by other designations. The substance called felspar predominates in most modern lavas: that called augite is most abundant. Hornblende is rare in modern lavas, though abundant in igneous rocks of more ancient origin. Quartz is also rarely exhibited in a separate form in recent lavas, though it forms so important an ingredient in granite and other rocks of igneous origin. The term trap is used by geologists to embrace all volcanic rocks of ancient origin, and is derived from the Swedish word for a step (trappa), from the fact that rocks of such a kind are often found in successive platforms, one above another. Trap rocks differ from lava in the fact of their having originated beneath the pressure of water, and their being intermixed with sedimentary deposits, while lava has issued directly from the mountain, and cooled under the influence of the atmosphere; the mineral character of each is, however, essentially the same. Torrents of water and mud often sweep down the mountain side during an eruption, and not unfrequently cause as much devastation as the more characteristic products of volcanic action. They are, no doubt, frequently (probably
in the great majority of instances) derived from the sudden condensation of aqueous vapour, as it rises into the higher and colder regions of the air. Sometimes the sudden melting of snow that has gathered round the mountain's summit, during its intervals of repose, produces a similar result. Frequent instances of the latter kind have been known to occur among the volcanoes of the Andes, many of which, Cotopaxi amongst the number, rise high above the snow-line, and are, for the most part, conspicuous by their icy and glittering covering. But in some instances there is no doubt that water is amongst the ejected products of the volcano, and with it thousands of fish, that have lived within the subterranean reservoirs of the mountain. Amongst the volcanoes of Central America, there is one called the Volcan d'Agua, or water volcano, from which streams of water are alone ejected.

41. Submarine eruptions are of not unfrequent occurrence, and their effects are by no means limited to merely temporary disturbance of the waters of the ocean. Many instances might be quoted of permanent elevation of the bed of the sea, and the formation of hidden rocks, perilous to the navigator, where there had been deep water previous to the eruption. Islands—in some instances permanent, in others only temporary—have thus been elevated from the bed of the sea by volcanic agency. One of the most striking examples of such a kind occurred in 1831, in the case of Graham Island, (as it has been most generally called), which was thrown up from the bed of the Mediterranean Sea, at a distance of about thirty miles to the southward of Sicily. At the end of June in that year, slight shocks as of an earthquake were felt by a vessel passing over the spot indicated, followed (about a fortnight later) by a column of water rising to sixty feet above the sea, with dense clouds of vapour. This was shortly succeeded by the appearance of a small island twelve feet high, with a crater in its centre whence volcanic matter and vapour were continually ejected, while the sea around was covered with floating cinders. The eruption continued for some weeks with great violence, the size of the island continually increasing by the accumulation of newly-ejected matter, until it attained its maximum dimensions of three miles in circumference, and more than two hundred feet in height. It afterwards gradually diminished, the loose volcanic matter being washed away by the waves. By the end of October, the island was nearly levelled with the surface of the sea, and afterwards wholly disappeared, leaving, however, where there had formerly been a depth
of more than a hundred fathoms, a dangerous reef, composed of solid rock, most probably lava.

[Several similar cases are on record in other localities, as in the neighbourhood of the Azores, off the coast of Iceland, and among the Aleutian Islands. A peculiar agitation of the waters of the ocean, as by some powerful force beneath, and quite distinct from the kind of movement due to atmospheric influences, is indeed by no means uncommon in the experience of mariners, and is often followed by the issue of smoke and gaseous matter above the surface of the water. A particular part of the Atlantic Ocean, in the neighbourhood of the equator, has been noticed as a locality in which such phenomena are of more than ordinary frequency.]

42. Mud-volcanoes—that is, small volcanic cones, from which take place periodical ejections of gases and water, mixed with mud—are amongst the many forms in which eruptive force is manifested. Their action has been frequently referred to some secondary cause (as the burning of inflammable strata below), rather than to any deeper-seated agency, but it is more probably correct to regard them as real volcanic phenomena, and to connect them with the widely distributed subterraneous heat of the globe: the fact of their occurrence only within volcanic regions lends strong confirmation to this view. Mud-volcanoes occur in the island of Sicily (near the town of Girgenti), in Java, and in the neighbourhood of the Caspian Sea. The volcanitos, or air-volcanoes, of New Granada, South America, described by Humboldt, may be classed with such phenomena. They occur in the neighbourhood of Turbaco (a few miles distant from Carthagena), about two miles to the eastward of that village, in the midst of a thick forest, which abounds in balsam-of-tolu trees, as well as in other rich productions of the tropical flora. The land gradually rises, as they are approached, to the height of 120 or 150 feet above the village of Turbaco; and, in the middle of an extensive plain, eighteen or twenty small cones are observed, each with an elevation of from twenty to twenty-five feet. These cones are formed of a blackish-grey clay, and an opening filled with water is found at the top of each. On approaching these little craters, there is heard, at intervals, a hollow, but distinct noise, which precedes by from fifteen to eighteen seconds the disengagement of a large body of air. Humboldt counted five explosions within two minutes. The phenomenon is frequently accompanied by an ejection of mud.

43. Geysers.—The geysers of Iceland are intermittent hot-springs,¹

¹ The word geysa, Icelandic, signifies to rage, or burst forth impetuously.
which, at irregular intervals, rarely exceeding twenty-four hours, throw up columns of boiling water and steam. In the case of the great geyser, the water is ejected to the height of from 80 to 100 feet, accompanied by subterranean noises and loud explosions, while sometimes the earth is slightly shaken. If stones are thrown into the circular mound out of which the fountain rises, they are instantly ejected with amazing force. The geysers rarely play for more than a few minutes at a time. In the intervals between its eruptions, the basin of the principal fountain is sometimes empty, but is more frequently filled with water in a state of ebullition. There is no doubt that steam is the immediate cause of the phenomena which the geysers exhibit. They occur amongst a thick bed of lava in the south-western part of the island, and at a distance of 30 miles from Mount Hecla. In this district, the rushing of water beneath the ground is frequently heard, and the streams, as in similar cases elsewhere, flow in subterranean channels through the cavernous lava. Geysers on the grandest scale—one of them ejecting water to a height of 250 feet—are also found within the upper portion of the Missouri basin, near the sources of the Yellowstone river. They occur also in the volcanic district of New Zealand.

44. Gradual rise or subsidence of Land.—To the more obvious and violent forms of volcanic action above described, there requires to be added one, in which the same agency operates much more slowly, and to outward appearance imperceptibly, in the production of a like result. The gradual rise or subsidence of large tracts of land is a well-ascertained phenomenon. A large part of Sweden furnishes an instance of this. Careful observation has shown that throughout the greater part of the Scandinavian peninsula, from the North Cape southward to the neighbourhood of Stockholm, there is a gradual rise of land, at a rate varying in amount from several feet to a few inches in a century. It is greatest in the extreme north of the peninsula, and thence diminishes to the southward. The extreme south of Sweden undergoes a movement in the opposite direction—i.e., a gradual sinking or depression. The seat of this continual, though slow, alteration of level between adjoining land and sea is far removed from any ordinary manifestation of volcanic agency. There are no volcanoes in either Norway or Sweden, though slight shocks of earthquake have been experienced in both countries. But the rocks of which the Scandinavian peninsula is chiefly composed are the product of igneous forces, belonging to former geological periods. Gneiss
and mica-schist are the prevailing rocks both in Norway and Sweden. The bare elevated mountain-plains of the former country consist principally of gneiss. Porphyry, greenstone, and other rocks of igneous origin, occur at intervals in Sweden. Granite is comparatively rare in both countries. The Scandinavian peninsula is geologically the oldest portion of Europe. If recent observations may be trusted, the eastern coast of Australia, in the neighbourhood of the Brisbane river, appears to be slowly rising to a higher level; as also does the southern coast of the same continent, about Rivoli and Guichen Bays (South Australia). Like phenomena of elevation and depression appear to be in operation in several parts of the North American continent, and also on the coast of West Greenland.

45. Coral Islands.—Among agents of change in the relative proportions and superficial contour of land and sea, the labours of the coral-worm, or polype, require to be included. Within the warmer latitudes of the globe, and in each of the three great oceans, there are found a countless multitude of islands, which owe their existence and constant growth to this apparently insignificant member of the animal world. The coral-worm (of which there are several species, all exhibiting a certain general resemblance) secretes from the waters of the ocean, by its own natural economy, the stony material which constitutes its home, and which is known to us as the coral-reef or island. The form most commonly exhibited by this polype is that of a little oblong-shaped bag of jelly, closed at one end, but having the other extremity open, and surrounded by tentacles, usually six or eight in number, set like the rays of a star. These tentacles, when stretched out, vary in length from four to six inches or upwards. Countless multitudes of these creatures are associated in the secretion of a common stony skeleton, the coral, or madrepore, the material of which coral islands are composed: the minute orifices of this rock constitute their dwelling-place, and when at work they may be seen beneath the water, protruding through these holes, and throwing out their tentacles in every direction; but when disturbed or molested in any way, they immediately withdraw, by sudden contraction, into their holes.

[The coral islands and reefs of the Pacific are scattered through a vast area of that ocean, between the parallels of 28° on either side of the equator. Coral

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1 The proofs of the gradual rise and subsidence of land in Scandinavia are derived from the altered depths of the harbours at successive periods; the changed position of various marks along the line of coast; the presence at some distance inland, and at some elevation above the water, of shells identical with those now living in the Baltic, with other circumstances of like description.
occurs abundantly upon the shores of Formosa, under the northern tropic; also in the Loo-Choo group (between 26° and 27° N. lat.), the Caroline Islands, and the Sandwich Islands. They are more especially numerous within the latitude of 10° S. and the neighbourhood of the southern tropic, and between the meridians of 134° west, and 135° east, of Greenwich. The multitudinous islands of Polynesia may, in fact, nearly all be brought under one or other of two great classes—those of volcanic origin, or of coral formation, and the latter are by far the more numerous. A great number of the volcanic islands, moreover, have coral reefs attached to their shores, and many are completely encircled by a belt of coral.

The Indian Ocean exhibits, in the long chain of the Maldive Islands, stretching through eight degrees of latitude, some of the most perfect examples of coral growth. Under the same meridian, the Chagos Islands, to the south of the equator, are of like origin. The Amirante Islands, in a more westerly part of the same ocean, consist entirely of coral, and the Seychelle group is based throughout upon a coral bank, though the islands themselves are of volcanic formation. Mauritius, again, is completely fringed by coral reefs, in which there are only two openings that allow of approach to its shores. The Red Sea abounds in corals, which stretch almost continuously along its shores on either side, and render its navigation in the highest degree dangerous.

The Atlantic Ocean furnishes fewer instances of coral-growth. The shores of Cuba, however, are thickly studded, through the greater part of their extent, with coral reefs, and many of the smaller islands of the West Indies—especially within the Bahama group—are surrounded by coral. The Bermudas, in lat. 32° 20', are entirely of coral formation, and form the south-eastern edge of an extensive bank of coral.]

46. Excepting in the case of the Bermudas, the islands and banks of living coral are nowhere at a greater distance than 28° from the equator, and those islands are but a few degrees beyond the general limit. The coral-polypes, in fact, only inhabit the warmer belt of the globe, where the range of surface-temperature probably does not fall below 70° of Fahrenheit. The reef-building members of the family, moreover, appear to be only capable of living within moderate depths, not exceeding, at most, twenty or thirty fathoms; so that the islands which are composed of coral must be based upon submarine formations of another kind. It is upon these submarine rocks—probably for the most part within a trifling distance below the surface—that the coral-worm commences its labours, and thence builds upwards until an elevation is reached over which the surf of the sea no longer washes, or which remains uncovered by the highest tides. The further labours of this marine architect are in a horizontal direction, since water is necessary to its existence, and they result in a continual increase of the limits of the reef which is in process of formation. Adjacent reefs thus become, in frequent instances, joined together, the
shallow intervening channel being gradually filled up by the growth of the coral-rock.

47. The rate of increase exhibited by coral reefs is various, according, probably, to many differences of natural condition. In some cases it appears to be very rapid, an interval of a few years sufficing to produce a striking change in the aspect of coral reefs, and in the depth of the surrounding waters. In other cases, but little change can be traced within a considerable term of years.

48. Although it is stated that the reef-building corals only exist in comparatively shallow water, yet it is not denied that other members of the same family of polypes are to be found at much greater depths. Living coral has been brought up from 100 fathoms and upwards below the surface, and corallines may probably exist at depths as great as any within which animal life can be supposed to be maintained. The reef-building polypes, however, are well ascertained to be inhabitants only of the limited depths above mentioned. They include several species, and the structures which these respectively rear exhibit characteristic differences. Some of them form large rounded masses, with numerous winding depressions, commonly known as brainstones; some are studded with holes, filled with shelly plates placed perpendicularly, and converging to a point in the centre; others assume the appearance of a mushroom; the most common form is that of an irregular, branching shrub.

49. Classification of Coral-reefs.—The most complete examination into the nature and growth of coral islands was that made by Mr. Darwin, whose work has deservedly become a standard of reference on the subject. Mr. Darwin classifies all the various forms of living coral under the three headings of lagoon islands (or atolls)—barrier (or encircling) reefs—and fringing reefs. He regards the areas within which these formations occur as regions of gradual subsidence, and shows how the fringing-reef of coral which is found in so many cases attached to the coast-line of intertropical islands passes, by a gradual sinking of the entire area, into a barrier reef (that is, an encircling belt of coral-rock, with a channel of greater or less depth intervening between the coral and the main body of the island); and the barrier reef into the condition of an atoll, in which coral alone is visible, as the last vestige of the original formation disappears below the waters,

1 From the resemblance which the convolutions of the coral bear to the lobes of the human brain.

2 On the Structure and Distribution of Coral Reefs.
and leaves only the encircling ring of coral, with an enclosed lagoon or still water. There is nothing in this theory in any way inconsistent with known truths respecting the physical condition of the globe, for, as we have seen, there are elsewhere regions, both of elevation and subsidence, exhibiting instances of slow and gradual action as well as of violent disturbance of the earth's crust.

50. The annexed diagram illustrates the manner in which, according to Mr. Darwin's theory, the gradual transition in the case of a mass of coral rock, from the condition of a fringing-reef to that of a barrier or encircling reef, and from the latter to that of an atoll or lagoon-island, may be produced by subsidence. The lines $A B$, $a b$, and $a \beta$, are supposed to represent three successive levels of the sea surrounding (and, in the case of the last, covering) an island to which reefs of coral are attached. When the land and water occupy the relative levels indicated by the line $A B$, the island stands at some height above the waves, and the attached coral ($c$) is in the condition of a fringing-reef—i.e., it skirts or fringes the coasts of the island. Supposing that, by subsidence of the land, the water subsequently occupies the place of the line $a b$, the coral (which during the process of subsidence, in virtue of well ascertained instincts on the part of the coral-worm, has continued to grow with most rapidity towards the outer edge of the reef, and to extend itself upwards, until the surface is reached) is then in the condition of a barrier or encircling reef, with an intervening channel between it and the body of the island. Suppose subsidence to continue until the water occupies, relatively to the land, the place of the line $a \beta$, the coral (which has continued to increase in the direction of the surface) then forms a ring or belt, enclosing a lake-like expanse of water, or lagoon.

51. The island-world of the Pacific furnishes examples of all three classes of coral formation. The atolls, or lagoon islands, are most
numerous, and almost entirely compose the groups which are collectively known as the Low Archipelago, immediately to the eastward of the Society group, as well as those that belong to the extensive region of the Carolinas. Both there and elsewhere the islands of this class are generally of circular or semicircular form, consisting mostly of a low belt or reef, which encloses a lagoon of smooth water, connected by one or more openings in the reef with the ocean outside. The form of an almost perfect circle is shown in the case of Whitsunday Island (S. lat. 19° 25', W. long. 138° 35'), but the semicircular form is much more commonly met with. In such cases the outer curve of the semicircle, that is, the convex portion of the reef, is invariably found to occupy the windward side of the island, the opening in the line of reef being always situated to leeward. In some cases the coral reef forms a complete ring, of circular or oval shape, and in others there is a double ring of coral, enclosing a lagoon of horse-shoe shape. The reef always slopes gradually on its inner side, towards the lagoon, but rises abruptly from the deep bed of the ocean, on its outer circumference. The height of the reef above the water rarely exceeds a few feet, and portions are covered over at high-water, or during storms.

The island of Bolabola, belonging to the Society group, furnishes a striking example of a barrier-reef. A plan of this island is exhibited in the annexed cut. The island itself is of volcanic formation, and its highest point reaches 4026 feet above the sea. But it is encircled, at the distance of about a mile from its shore, by a belt of coral, between which and the island itself there is a channel of deep and still water. The reefs which similarly enclose Tahiti and others of the Society Islands, together with the islands of the Fiji group, and also those which nearly surround the shores of New Caledonia, are of this description.

The shores of north-eastern Australia supply an example of a barrier-reef on a scale of vastly greater magnitude than is elsewhere

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1 A few of the coral islands reach various elevations (from one to five hundred feet) above the sea. These have evidently been raised by volcanic agency, at some period subsequent to their original formation.
found. Through a distance of more than twelve hundred miles in a direct line, from Cape York, at the northern extremity of the Australian continent, southward to Hervey Bay (S. lat. 24° 30'), the coast-line is everywhere fronted, at a distance which varies from ten or fifteen to a hundred miles, by a nearly continuous succession of coral reefs, lying only just below the surface of the water, and broken through in its upper portion by numerous narrow openings. These are collectively known as the "Great Barrier Reef." Between the reefs and the shore of the mainland there is a channel, of moderate depth, which affords a safe passage for ships. Upon its outer side, towards the open ocean, the reef rises perpendicularly from a depth, on the average, of not less than 2000 feet.

54. The reefs which surround the Sandwich Islands, in the North Pacific, and those of the Navigator and Friendly groups, in the southern half of that ocean (like those which encircle the island of Mauritius, in the eastern hemisphere), are instances of fringing reefs. The Maldive and Chagos groups, in the Indian Seas, are atolls, or lagoon islands. The Keeling (or Cocos) Islands, in the same ocean, are another example of the like kind.

Coral islands supply instances of change, the result of living agency, which is of high importance when regarded as extending through lengthened periods. The reefs which the coral polype rears up to the level of the ocean become, in course of time, the habitation of man. The coral ceases to grow higher when no longer washed by the surf or rising tide; but it spreads in a lateral direction, and the height is gradually increased by various matter which the sea throws up during storms. The sun acts with intense force upon the newly-erected mass of rock, and, under the combined influence of the atmosphere and the sun's rays, the surface becomes gradually, in greater or less degree, pulverised into a covering of calcareous sand. The winds and currents bring the germs of vegetable and animal life, which are cast upon its shores. The cocoa-nut palm, especially, readily acquires a footing. "Entire
trunks of trees, which are carried by the rivers from other countries and islands, find here at length a resting-place, after their long wanderings; with these come small animals, such as lizards and insects, as the first inhabitants. Even before the trees form a wood, the real sea-birds nestle there; strayed land-birds take refuge in the bushes; and at a much later period, when the work has been long since completed, man also appears, builds his hut on fruitful soil formed by the corruption of the leaves of the trees, and calls himself lord and proprietor of this new creation."

55. It is not unusual to find fresh water upon coral islands,—if not upon the surface, by digging down to the depth of a few feet. This is probably to be accounted for by infiltration of the sea-water through the coral-rock. In like manner, fresh water may often be obtained, upon a line of sandy beach, by digging holes to a moderate depth, and allowing them to become filled by infiltration.

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EXAMINATION QUESTIONS.

1. What kind of changes in the aspect of the Earth's surface are classed as aqueous? Give some examples from the coasts of Western Europe, including the British Islands.

2. Give some instances of the influence of rivers in producing physical changes.

3. What are land-slips, and how are they occasioned?

4. What are igneous changes, and what observed conditions in the temperature of the earth's crust point to the existence of subterranean heat?

5. Over what geographical areas are earthquakes distributed? Trace these on Map of the World, in connection, successively, with the Pacific, Indian, and Atlantic Oceans.

6. Give some account of the phenomena which attend a violent earthquake, and especially of the different kinds of motion which may accompany the shock.

7. What is the characteristic aspect of a volcanic mountain? Name three or four of the higher volcanoes of either hemisphere.

8. Describe some of the more striking accompaniments of a volcanic eruption, particularly as to the lava which sometimes issues from the mountain.

9. What are submarine eruptions? In what parts of the globe have they been experienced?

10. Where are the geysers? Give some account of them.

11. In what parts of the world has evidence of gradual rise, or subsidence, of land been obtained?

12. What are Coral Islands? What classification of coral-reefs has been proposed by Mr. Darwin?

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1 Chamisso.
GEOGRAPHICAL DISTRIBUTION OF MINERALS.

1. The distribution of minerals constitute an important chapter of Physical Geography, and one that is intimately connected with the advancement of nations and the industry of mankind. Countries are very variously circumstanced in this regard—some being as deficient in the more useful productions of the mineral world as others are in the precious metals, or the reverse. In the case of some regions, there exists comparatively little material for the exercise of mining industry, while in other instances (of which our own country furnishes the most conspicuous example) nearly every district has its characteristic mineral deposits or metallic ores.

2. Coal.—Of all the productions of the mineral world, coal is of most direct value to civilised man. This indispensable mineral is, fortunately, of tolerably extensive distribution, and the known area of its diffusion becomes continually enlarged by the extension of inquiry into regions hitherto only imperfectly known. Two regions, however, greatly surpass any others in the extent and amount of produce of their coal-fields: these are, Great Britain and the eastward division of the United States—both situated within the northern temperate zone. The first-named, though occupying by much the smaller area, is vastly superior to all others put together in the amount of its produce. The annual coal-produce of Great Britain is now upwards of 163,000,000 tons, which is more than half the total produce of the globe.

3. The coal-producing regions of Europe are the British Islands, Belgium, France, Prussia, and other parts of Germany (including Saxony, Bohemia, Hanover, and the Tyrol), with, in smaller quantity, Spain, Russia, and Sweden.

The extensive distribution, and vast importance, of the coal-fields of Great Britain are well known. The northern and midland counties of England, the southern counties of Wales, and the lowland division of Scotland, include the more important of the British coal-fields.
Those of South Wales, Durham and Northumberland, Yorkshire, Lancashire, South Staffordshire, and North Staffordshire, are superior to any others in point of extent, and the region of their occurrence coincide, as is well-known, with the great localities of British manufacturing industry. The coal-producing districts of Ireland are of limited extent, though the carboniferous formation enters largely into the geology of that island. The produce of the Irish coal-fields amounts to less than one five-hundredth part of the total coal-produce of the British Islands. The total area of the British coal-fields is estimated at 2,779 square miles.

The amount of the coal-produce of Belgium exceeds 18,500,000 tons annually. The total area of its coal-fields, however, does not exceed 520 square miles, chiefly within the provinces of Hainault and Liege.

The coal-fields of France are scattered over a wide area of that country, but are all of limited extent. The most productive is that in the neighbourhood of St. Etienne, within the basin of the upper Loire. The total annual produce of the French coal-fields is about 21,446,000 tons.

Amongst the coal-fields of Germany, those of the Saar and Ruhr valleys¹ (both within the Prussian territories), of Bohemia, Prussian Silesia, and Bavaria, are the most important. The German coal-fields yield above 55,000,000 tons annually.

In Spain—a country abounding in the most various mineral produce—the coal-fields are of considerable extent, but are little worked. Those in the province of Asturias are the most valuable.

4. The coal-producing countries of Asia comprehend India, China, Japan, Persia, Syria, Asia Minor, Burmah, and the island of Labuan, in the Malay archipelago.

The coal-fields of India cover a considerable area, and already yield a large amount of produce—capable, it would seem, of considerable extension. The Raneegunge collieries (situated 126 miles to the N.W. of Calcutta, within the district of Burdwan), are more largely worked than any others. The coal deposits form a belt which stretches across the entire breadth of India, from the peninsula of Cutch on the west, to the extremity of Assam in the east, through more than 30° of longitude. The Chinese coal-fields are of vast extent,

¹ The river Saar is an affluent of the Moselle, within the Rhine Province of Prussia; the Ruhr joins the Rhine on the east bank of that river, and chiefly within the limits of Westphalia.
The little island of Labuan, situated off the N.W. coast of Borneo, and since 1846 a possession of Britain, derives its chief value from its abundant coal strata. The coal is worked through the agency of British capital, and Labuan has become a depot for the supply of steamers navigating the eastern seas.

5. In Africa, coal appears, from the observations of Dr. Livingstone, to be distributed over an extensive area of the Zambesi valley, and also occurs within the colony of Natal. Good coal is found in the island of Madagascar, where it is worked by the natives.

6. The coal-fields of North America come next to those of western Europe in point of value, and greatly surpass them in point of extent. The coal-fields of the United States spread over an area of 196,800 square miles, and those of British North America (including Vancouver Island) cover above 7,000 square miles.

7. Of the United States' coal-fields—which annually produce about 96,000,000 tons of coal—the most important is the Alleghany or Pittsburg coal-field, which stretches through portions of Pennsylvania, Ohio, Western Virginia, and the adjacent states. The town of Pittsburg, at the junction of the two arms of the Ohio river, is the Birmingham of the New World. The Illinois, Michigan, and Missouri coal-fields are each of great extent and value. The Richmond coal-field, in Eastern Virginia, which is of considerable value, is remarkable as belonging, not to the carboniferous period of geologists, but to the limestones of the oolitic series.

8. Within British North America, the coal-fields of New Brunswick, and also those of Cape Breton and Prince Edward Islands, are of high value. Coal occurs on the western coast of Greenland, in lat. 70°, where it is worked by the Danish settlers, and also in several of the islands of the Arctic archipelago. Upon the opposite side of the continent, Vancouver Island has been found to contain valuable coal-strata, which, since the period of its colonization by Britain, have been profitably worked, and promise to become of high importance in connection with the growing steam-navigation of the North Pacific. In South America, Chili contains coal, the beds of which are worked to a considerable extent, and are of increasing value. In the West Indies, coal occurs in the island of Cuba, in the neighbourhood of Havana.

9. In Australia, the colony of New South Wales includes valuable coal-fields, estimated to cover an area of 28,840 square miles. It also
occurs in Queensland and in Victoria. Good coal is also worked in Tasmania. The same valuable mineral occurs in several places in New Zealand, both in the North and South Islands.

10. Iron, the most indispensable of metallic substances, is of even wider distribution than coal. There is, happily for man, no production of the mineral world which has such wide geographical limits. In one or other of its various forms, iron-ore occurs in nearly every region of the globe, and in connection with formations which hold widely-distant places in the geological series. In our own country, the carboniferous series of rocks are the great seat of the iron workings of the present day; but the same metal enters extensively into other stratified formations, occurring abundantly among the limestones of the oolitic series, the wealden group, and elsewhere. It is within the carboniferous area, however, that iron can be most profitably worked, from the occurrence there, in immediate proximity, of iron, coal, and lime—that is, of the ore, the fuel, and the necessary flux, or medium, for the conversion of the ore into the workable metal.

11. Of European countries, those which furnish iron in the greatest abundance are Great Britain, Belgium, France, Russia, Germany, Sweden and Norway, Italy, and Spain. The quantity of iron-ore raised annually in Great Britain and Ireland is upwards of 17,000,000 tons, which exceeds the supply furnished by any other single country, and equals in amount that supplied by all the other chief countries in the world, taken together. Belgium—rich in iron as in coal—though producing only 250,000 tons of iron-ore, supplies above 1,500,000 tons of pig and wrought iron.

12. The iron deposits of the Scandinavian peninsula possess a high degree of value, and the Swedish iron yields the best steel in the world. In Russia, iron ore occurs extensively in widely-distant parts of the great plain, and also within the southwardly portion of the Ural Mountains. The province of Styria (Austria) furnishes a large quantity of iron of excellent quality, equal to any that is made in Europe. In the south of Europe the iron-mines of the island of Elba have been worked during the last two thousand years.

13. In Asia, iron is distributed over a vast area. Asia Minor, Georgia, Armenia, Persia, India, Siberia, Japan, and some of the islands of the Malay Archipelago, all furnish it, in greater or less proportion. The iron-workers on the north-eastern coasts of the lesser Asia, along the shores of the Black Sea, follow the same occupation now that their ancestors did in the days of Xenophon. In India, iron is worked in many parts of the Carnatic, and also on the Malabar
coast: it occurs likewise in Northern India, within the elevated region of the Himalaya.

14. Iron occurs in widely-distant localities of the vast African continent—from the Atlas region in the north (where it is worked within the French province of Algeria) to the Cape Colony and the regions bordering on the Zambesi, in the south and south-east.

15. In the New World, the iron produce of the United States is of high value, and is superior in amount to that of any other country, excepting Britain. The district within which it is principally worked coincides with that of the more considerable coal-fields. Canada, within its westerly province (Ontario), and especially to the north of the great lakes, is a country of rich mineral produce, iron being amongst its stores of native wealth. New Brunswick, Nova Scotia, and Cape Breton Island, also contain iron-ore.

16. In South America, Brazil, New Granada, Bolivia, Chili, and La Plata, are enumerated among the countries in which iron exists, though as yet it is nowhere worked to any advantage.

17. Australia has iron-ore distributed through an extensive region, embracing parts of New South Wales, Victoria, West Auckland, with the neighbouring island of Tasmania. New Zealand also contains workable ores of this metal.

18. Copper is one of the most widely diffused metals—it occurs in each of the six continents.

19. Copper is found in Europe chiefly in the following countries—British Islands, Spain, Russia, Hungary, Sweden and Norway, Turkey, and Germany. In Great Britain, it is principally in the counties of Cornwall and Devon that copper is worked. Anglesey and other parts of Wales, with the Isle of Man, and the county of Wicklow, in Ireland, also supply some quantity. A vast quantity of copper-ore from other parts of the world is brought to Swansea to be smelted. The copper mines of Norway possess high value: those of Sweden are less productive now than formerly. Spain abounds in rich ores of copper.

20. In Asia, Asia Minor, Armenia, Siberia, India, China, Japan, Persia, and some of the East Indian islands, supply copper, but none of them in any considerable quantity. The copper of Japan, however, is of the finest description, and is used extensively in that country for works of utility and ornament: some also is exported thence to Europe.
21. In Africa, it is only in Algeria and South Africa that copper is worked to any noticeable extent; but the ore is known to occur in widely-distant regions of that continent, both towards its northern and southern limits, and on the eastern and western coasts to the south of the equator.

22. In North America, copper occurs abundantly in the western division of Canada, in the vicinity of Lake Superior. In the southern half of the New World, Chili, Peru, Brazil, and other countries adjacent to the Andes, contain abundant copper-ores, which are worked in Chili, on a scale of great extent. The copper supplied by Chili has of late years greatly exceeded in quantity that derived from any other source, and in 1883 the quantity exported to Great Britain was valued at £1,670,000. The island of Cuba has also valuable copper-mines. The copper both of Chili and Cuba is an article of extensive import into Britain, the ore being brought to Swansea for the purpose of smelting.

23. South Australia contains a rich abundance of copper-ores. The history of the famous Burra-Burra has, indeed, been the history of the commercial progress of the colony. The Wallaroo district, within the peninsula that intervenes between St. Vincent and Spencer Gulfs, contains mines of even greater value. Copper occurs likewise in New South Wales, Victoria, West Australia, Queensland, and other parts of Australia.

24. Tin, a scarce but valuable metal, is derived chiefly from the mines of Cornwall, and from the island of Banca, in the East Indies.

25. The tin of Cornwall has been worked from a very early period, and attracted the mariners of Phoenicia to the shores of Britain many centuries before the Christian era. The only other countries of Europe which supply tin, to any noteworthy extent, are Spain (where it occurs in the province of Galicia) and Bohemia. The island of Banca, lying to the eastward of Sumatra, abounds in tin-ore of the finest quality. It is extensively exported thence to Europe. Tin occurs also in other parts of the Malay archipelago, and likewise in Burmah, Assam, and the Malay peninsula. Large quantities of tin-ore occur in the United States. Both Mexico, Peru, and Chili supply a limited quantity of the same metal; and large quantities have been discovered within recent years in New South Wales (where it is found in the beds of rivers and creeks, and also in veins and lodes), Victoria, Queensland (the supply is practically inexhaustible—the stanniferous area being 225 square miles), Tasmania, and New Zealand.
26. **Lead** occurs more abundantly in *Spain* than in any other country of Europe. The Spanish mines, both of lead and other ores, have been worked from a very early period, and yielded a large supply under the Romans. The variety and richness of the ores of lead which are distributed throughout the Spanish peninsula are described as truly astonishing. Lead enters likewise into the native produce of Great Britain and Ireland, Carinthia (Austrian Empire), Bohemia and other parts of Germany, Hungary, Transylvania, France, Belgium, Norway, Portugal, and Turkey. The lead mines of Carinthia supply a pure and exceedingly valuable description of lead: those of Bleiberg (seven miles W. of Villach) are among the most celebrated.

27. In *Asia*, the countries producing lead are Siberia, Armenia, India, China, Siam, and Japan. The lead mines of Siberia are chiefly within the Trans-Baikal province, to the eastward of Lake Baikal.

28. In *Africa*, it is only in the region of the Atlas, within the French province of Algeria, that lead mines are worked; but the ore of lead is extensively distributed over other regions of that continent.

29. In the *New World*, lead occurs in the United States, also in Canada; and in most of the countries of South America, especially in Chili. Lead is also to be included amongst the various mineral wealth of the Australian continent.

30. **Zinc**,¹ in one or other of its two ores—calamine and blende—is supplied chiefly from the mines of England and Wales, Prussia and various parts of Germany, Belgium, Spain, the United States, Chili, China, and Victoria.

31. **Quicksilver**, or mercury—a metal of extensive use in the arts, and distinguished from other metals by its fluid form (unless at lower temperatures than 39° below zero of Fahrenheit)—is of limited dis-

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¹ Zinc, which is one of the most extensively distributed of metals, is not found in a native state. The two ores from which it is extracted are *calamine* and *blende*—the former an oxide, the latter a sulphuret of zinc. Calamine (from which the larger proportion of zinc is derived) is found in China, in Siberia, the United States, Hungary, Carinthia, Silesia, and France; also in our own country, as at Mendip, in Somersetshire; Matlock, in Derbyshire; Wanlock-head and Lead Hills, in Scotland, and other places. One of its chief depositories is Limburg, in the Netherlands. Calamine is often found as an accompaniment of lead. Blende, or the sulphuret of zinc, occurs in Wales, Derbyshire, Cumberland, and Cornwall, and also in various parts of the European continent. It is almost always found either in connection with rocks of primitive formation, or in the compact limestones of the secondary series. Though now employed for a vast number of useful purposes, zinc was until a recent period disregarded as comparatively worthless. Calamine, however, was used in the making of brass, which is an alloy of zinc and copper.
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tribution in a native state. The mines of Idria, in the Austrian province of Carniola, and those of Almaden, in the province of La Mancha (Spain), furnish the chief supply of quicksilver, derived from European sources. In Asia, both China and Japan possess quicksilver, and a considerable quantity was formerly imported into England from the former country. In the New World, Huancavelica, in Peru, was long the chief source whence quicksilver was derived, but valuable deposits of this metal have been found in California and Mexico.

32. The mines of Almaden, in Spain, lie within one of the tributary valleys of the Guadiana basin; the metal is worked in veins of considerable thickness, which occur in the palæozoic rocks of La Mancha. Notwithstanding the operations actively carried on there for centuries, the depth hitherto reached does not exceed 150 fathoms: the principal vein has a thickness of from 30 to 50 feet. These mines furnish annually upwards of 1000 tons of mercury. The quicksilver mines of California surpass those of all other regions unitedly in amount of produce, and regulate the prices of this valuable metal throughout the world.¹

33. In California, and other gold-producing regions, quicksilver is necessarily employed for the purpose of separating the gold from the quartz rock in which it is imbedded. There has hence arisen an increasing demand for this metal since the gold discoveries of recent times. It has the property of uniting readily, as an amalgam, with nearly all the metals, excepting iron.

34. Gold.—Of the precious metals, gold takes the first place in importance. Prior to 1848, the gold-fields of Siberia supplied by much the largest quantity of gold, and those of South America (particularly Brazil) came next in order of value.² But the gold-fields of California, first discovered in that year, and those of Australia, discovered three years later, now far surpass any others in importance.

35. The gold-fields of California are situated within the valley of the river Sacramento, which, deriving its waters from the high chain of the Sierra Nevada, on the western side of the North American continent, and flowing to the southward through a long valley, between

¹ The most valuable of the Californian mines are the New Almaden, situated about 60 miles S.E. of San Francisco. The quicksilver is here derived from an ore of cinnabar, by a process of smelting.

² Before the working of the Californian and Australian gold-fields, the total annual produce of gold was less than £10,000,000, of which the Siberian mines alone contributed about £4,000,000. The annual gold produce of the world has been more than trebled within recent years.
that mountain range and a lower chain more immediately adjacent to the coast, enters the fine bay of San Francisco, in lat. 38°. The gold, derived in the first instance, and for several years succeeding its first discovery, from alluvial washings at the base of the higher ground, is now obtained chiefly by means of crushing the quartz rock in which the metal is imbedded. Here, as in other gold regions, the quartz forms an integral portion of the palæozoic rocks which compose the mountain-system. The quantity of gold derived from the Californian gold-fields since the date of their being first worked has averaged above £12,000,000 annually.

36. The province of British Columbia, also situated on the western side of the North American continent, between the Rocky Mountains and the Pacific, owes its formation into a distinct colony (in 1858) to the discovery of rich gold-fields within the valley of the Fraser river, which enters the Pacific in lat. 49° 10'. The group entitled Queen Charlotte Islands, within the adjoining ocean, also contain gold. Upon the opposite side of the North American continent, Nova Scotia has gold-fields of some value.

37. The gold-fields of the great southern land—Australia¹—rival those of California in abundance of produce, and perhaps extend over a larger area. The province of Victoria includes the principal regions of auriferous deposit. The gold-fields of New South Wales, Queensland, and Tasmania are of much less value. The auriferous region extends along the entire inland range of the cordillera of eastern Australia, through a range of six hundred miles. In the Australian gold-fields, as in the like instance of California, the first workings were confined to the alluvial deposits, but as these were gradually exhausted, the process of quartz-crushing had to be resorted to. The Australian Alps, with other portions of the prolonged mountain-cordillera of which they form a part, consist chiefly of palæozoic rocks, among which the quartz occurs in veins. In New Zealand, also, gold mining is conducted on a large scale—the total exports up to the present time amounting to nearly 10,000,000 oz.²

Within Europe, the countries whence gold is chiefly obtained are Transylvania and Hungary. The gold-mines of the Ural Mountains, with one exception, are all situated upon the Asiatic side of the chain. Small quantities of gold are obtained from workings situated within the higher Alpine valleys, chiefly upon the Italian side of the mountain-region; also from the Spanish

¹ Total quantity since 1851, estimated at 73,493,423 ozs., valued at £289,240,451.
² In 1884 the value of the gold exported was £950,134.
peninsula, and from the group of the Wicklow Mountains, in Ireland: but the total value of these sources of produce is extremely trifling.

In Asia, Siberia ranks first in importance as a gold producing region. Both the Ural and the Altai are regions of auriferous deposits, but the gold-mines of the Ural are in great measure worked out, while those of the Altai region are increasing in importance. The gold-fields are chiefly within the high grounds that divide the upper courses of the three great Siberian rivers—the Obi, Yenesei, and Lena—embracing especially the valleys watered by the smaller tributaries of the two former streams. Tibet, China, Burmah, Siam, the Malay Peninsula, Cochin-China, Tonquin, and Japan, with Borneo and some other of the islands of the Malay Archipelago, are also to be enumerated among the gold producing regions of Asia. The gold-mines of Borneo are worked by the Chinese settlers, on the west coast of the island, under the direction of the Dutch. 

Africa has gold for its most characteristic article of mineral produce, but the quantity derived thence in the present day is trifling in point of value. Both the eastern and western coasts, within the tropics, supply gold—chiefly in the form of sand. It is also found in the Transvaal. Some of the tract of interior Soudan, between the head-waters of the Niger and Senegal rivers, are also rich in this metal.

In the New World, besides the valleys of the Sacramento and the Fraser, the gold-producing regions include Nova Scotia, Mexico, and Central America; with Brazil, New Granada, Bolivia, Chili, and La Plata. The mines of Mexico, Peru, and Brazil, long furnished the chief supply of the precious metals to the rest of the world, but comparatively few of them are now worked to any advantage.

38. Silver is frequently found in combination with other metals, especially with copper and lead. Most of the lead-mines in our own country furnish a greater or less quantity of silver. The principal countries which furnish silver, in its native state, are—in Europe, Hungary, Bohemia, Transylvania, Saxony, Hanover, Turkey, Norway, and Spain. In Asia, Siberia and China; in the New World, Mexico, Peru, Bolivia, New Granada, Chili, La Plata, and the United States.

39. Peru and Mexico furnish, in the present day, by far the greatest quantity of native silver. Potosi (in the modern state of Bolivia), the mines of which were so long celebrated, is now of little or no value in this regard, but a vast number of mines are worked in other parts of the Andes. A large amount is also obtained from the territory of Nevada, in the United States; and a limited quantity is found in New South Wales, South Australia, and New Zealand.

1 The mines of Spain anciently yielded the chief supply of silver, as well as of copper and lead, to the Romans. The enormous heaps of slag, known as Roman scoriæ, the refuse of their works, still contains a sufficient quantity of silver to pay for their working. In England, similar accumulations in the Mendip Hills (originally Hyme Deep) are smelted for the sake of the silver they contain.
40. Platinum, a valuable and scarce metal, is chiefly derived from mines in the Ural Mountains, where, however, it has been worked only since 1824. It occurs also in South America, in parts of Brazil and New Granada, and likewise in Spain. It is only in Russia, however, that it is used to any noteworthy extent.

41. The complete list of metals known to modern science comprehends not fewer than forty-three distinct substances. By far the greater number of them, however, are of rare occurrence, and of exceedingly limited utility, as compared with the few that have been noticed above. Among those that rank next in point of general utility, bismuth, antimony, manganese, nickel, cobalt, and arsenic may be mentioned. Bismuth, a scarce metal, chiefly employed for the purpose of alloys (as pewter, &c.), is principally derived from Saxony. It occurs also in Siberia, and, to a small extent, in Cornwall, Victoria, and South Australia. A lode of Bismuth has been discovered at Mount Ramsay, in Tasmania, and is said to be one of the richest, if not the richest, in the world, but it has not yet been turned to practical account. Antimony, which is employed for like purposes, and especially in the composition of type-metal, is supplied by France and Hungary. It occurs also in Spain, and both in England and Scotland. Of late years, however, the province of Sarawak, on the north coast of Borneo, has proved the largest source of supply. It is also found in New South Wales, Victoria, Queensland, Tasmania, and New Zealand. Manganese is derived from Devon and Cornwall, in our own country, and from various portions of Germany (within the mining districts of Saxony, Hanover, and elsewhere), also from Hungary, France, New South Wales, and Victoria. Nickel (employed in the manufacture of German silver, and in various other forms of alloy) occurs in Saxony, Bohemia, France, and Cornwall. Cobalt—employed in a great number of manufacturing processes, for the sake of its colouring qualities—is derived from several ores, which are found chiefly in Spain, France, Saxony, Bohemia, and other parts of Germany, and also in Cornwall. Arsenic, in its native state, is chiefly derived from Germany (principally the mining districts of Saxony and the Hartz), Hungary, Transylvania, Siberia, and France. It is also found in New South Wales.

42. Sulphur, one of the most valuable of combustible minerals, is derived chiefly from the island of Sicily, where it occurs in vast abundance. It occurs, however, in various countries, within either division of the globe, and especially within volcanic regions. Sulphur is found abundantly in Spain, where it occurs under all its different con-
ditions—native, earth-combined, and in sulphuric nodules. **Graphite** (from which the so-called black-lead pencils are made) comes under the same division of the mineral kingdom. It is an exceedingly valuable and rare mineral, nowhere else found of quality equal to that in the valley of Borrowdale, in Cumberland, immediately to the south of Derwent-water, where it occurs in a bed of trap rock alternating with clay-slate. Graphite, however, occurs in many other countries, both in the Old and New World. Large quantities of it has been found at Wellington in New Zealand.

43. **The Diamond.** First in order of value amongst precious stones, is ranked by the mineralogist amongst combustible minerals, since it is really pure crystallised carbon, inflammable at a very high temperature. It is from Brazil that diamonds are chiefly derived in the present day. The districts of India which formerly yielded this brilliant gem have long since been nearly exhausted. Within recent years, diamonds of considerable value have been found in South Africa, near the junction of the Vaal with the Orange River, and to a much less extent in New South Wales.

44. Of other precious stones, the emerald is chiefly derived from Peru and some of the neighbouring countries of South America; the ruby from Burmah, and also (more rarely) from Ceylon; the amethyst and topaz, from Ceylon and China; the turquoise, amethyst, jasper, topaz, cornelian, and others of less value, are found in various parts of India, Turkestan, and among the mountainous tracts adjoining the Altai and Himalaya systems, as well as in the like regions of Russia, Hungary, Transylvania, and other parts of Europe.

45. **Salt.** Of all the various substances which compose the mineral kingdom, there is none that enters more into the supply of the daily wants of man than common salt, which is a compound of soda and muriatic acid. The ocean, in which it everywhere exists in solution, is the great reservoir of this indispensable substance. It occurs, however, in the form of a solid mineral, over vast areas of the globe, and is also extensively obtained, in Britain and other countries, from brine-springs. In England, the great supply of salt is obtained from the new red sandstone formation, within the valley of the river Weaver, in Cheshire; to a less amount, but under like geological

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1 Though bearing, in popular language, the synonyms of plumbago, or black-lead, graphite has really not a particle of lead in its composition. It consists chiefly of carbon, mixed with a small portion of iron.

2 In 1883 the total quantity of salt produced in the United Kingdom was 2,325,000 tons, of the value of £660,760.
conditions, from the neighbourhood of Droitwich, in Worcestershire. The salt-mines of Bochnia and Wielicza, in Austrian Poland, or Galicia, are among the most famous in the world, and furnish a large supply. The tract of the Lower Steppes, in the south-eastern portion of European Russia, exhibits a soil which is largely impregnated with salt, and the small lake of Ielton, in the adjoining district, to the eastward of the Volga, supplies a large portion of the consumption of the Russian empire. The Salt Desert of Persia exhibits, over an area which embraces many thousand square miles, a saline efflorescence covering the ground, and causing it to sparkle in the distance. There are like tracts in other parts of the world, which have been elsewhere referred to. On the coasts of Spain, Portugal, France, and numerous other countries within warm latitudes, there are extensive salines, from which salt is obtained by evaporation from the water of the sea.

Examination Questions.

1. From what parts of the world are supplies of coal chiefly derived? What proportion does the coal produce of Great Britain bear to that of other countries?

2. Give some account of the coal-fields of the United States, and point out their locality on the Map of North America.

3. What countries of Europe furnish iron most abundantly, and what relative place does Britain hold amongst them?

4. From what countries of the New World is copper derived, and from which of them in the largest quantity?

5. Whence is tin chiefly derived? Point out the locality of tin on the Map of Asia.

6. What parts of Europe include the principal lead-mines?

7. Whence is quicksilver chiefly derived?

8. What regions include, at the present time, the most productive gold-fields? Point to their localities on the Map of the World.

9. What countries of Europe furnish gold? What countries of Asia?

10. What countries furnish the chief supply of silver? With what other metal is silver generally found associated?

11. Whence is platinum derived?

12. From what regions are the following chiefly derived—bismuth, antimony, manganese, nickel, cobalt, arsenic, and sulphur?

13. What is graphite? Whence is it obtained, and for what uses is it employed?

14. In what countries are the following chiefly found—diamond, emerald, ruby, amethyst, and corneian?

15. Indicate on the map some of the principal localities of salt.
XIII.

DISTRIBUTION OF PLANTS.

1. Botanists recognise more than a hundred thousand species of plants—including in the latter term every description of vegetable life, from the largest forest-growth to the minutest forms of vegetation. The distribution of this varied abundance of vegetable life over the earth's surface is in great measure regulated by the conditions of physical geography that have been described in the preceding chapters. Light, heat, and moisture, are necessary (with few exceptions) to the development of vegetable life, and the various measure in which they are combined serves in no small degree to regulate the capability of any region for particular kinds of culture. Thus, the combined heat and moisture of tropical countries favours the luxuriant development of forms of life which only attain a diminutive growth beneath colder skies. The more arid regions of the earth are the seat of a vegetable growth which is altogether distinct from that proper to moister regions; and this, again, differs in the case of aridity combined with heat from that of the same aridity under colder latitudes. The lengthened periods of alternate light and darkness proper to the climate of polar regions are attended by correspondent peculiarities in the classes of plants that are adapted by nature to such conditions of growth.

2. Zones of Vegetation.—Irrespective, however, of any considerations concerning the peculiarities of vegetable organism, the influence of climate upon plants is sufficiently obvious, and is illustrated in numerous instances which are familiar to common observation. The flora\(^1\) of the torrid zone differs widely from that of the temperate regions of the globe; that of the temperate zones from the vegetable growth of polar latitudes. But this mere division of the earth's surface into astronomical zones is insufficient to express the generalised truths which the transition in the forms of vegetation, from the heat

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\(^1\) The word flora is used to express the vegetation of any particular region; the parallel term fauna indicates its animal life.
of the equator to the cold of the polar regions, embodies. Adopting
as their designations such terms as express, in a general manner, the
distinguishing characteristics of their vegetable forms, Humboldt
divides the space between the equator and either pole into—

(1) A zone of **Palm**s and **Banana**s (Equatorial), ranging from the Equator
to about 15° N. and S. latitude.

(2) A zone of **Tree-Ferns** and **Figs** (Tropical), ranging from 15° to about
25° lat. in the northern, and 23° in the southern hemisphere.

(3) A zone of **Myrtles** and **Laurels** (Sub-tropical), ranging between 25°
and 35° in the northern, between 23° and 30° in the southern hemi-
sphere.

(4) A zone of **Evergreens** (Warm Temperate), ranging between 35° and
45° in Europe and Western Asia; in the New World, and also in
Eastern Asia, scarcely reaching so far north as 40°: in the southern
hemisphere, between 30° and 40°.

(5) A zone of **Deciduous** Trees (Cold Temperate), ranging between 45°
and 55° in Western Europe; over the greater part of the Old World,
and also, for the most part, in the New World, lying rather between
38° and 45°; in the southern hemisphere, from 40° southwards.

(6) A zone of **Conifers** and **Edible Berries** (Sub-Arctic), ranging in Western
Europe between 55° and 66°, and nearly as high on the west side of
North America; elsewhere, between 45° and 55°. In the southern
half of the globe, only the extremity of the New World falls
within this belt.

(7) A zone of **Lichens**, **Saxifragés**, and **Dwarf Shrubs** (Arctic), ranging
on the west side of either continent between 66° and 72°; through
the greater part of both Old and New Worlds, between 55° and
60°; in Eastern Asia, and on each side of North America, not so
high.

(8) A zone of **Lichens** and **Mosses** (Polar), reaching from the limits of the
last mentioned zone in the direction of the Pole.

3. The dividing lines between the above zones are coincident with
isotherms rather than with parallels of latitude, for, as we have else-
where seen, temperature is dependent upon various conditions besides
mere distance from the equator. The zones themselves hence con-
stitute so many waving bands which stretch round the globe, rising
or falling to greater or less distances from the pole, in the same way
as the isotherms themselves.

The first of the above zones, which has a mean temperature varying between
82° and 78°, may be regarded as the natural region of the palms and bananas,
together with the spices (clove, nutmeg, &c).

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1 That is, plants which cast their leaves annually: Latin, *decidere*, to fall.
2 That is, trees of the pine and fir tribe. The conical form of the fir-apple, common
to that family of trees, illustrates the meaning of the term.
The second zone, within which the mean temperature decreases from 78° to 73°, is the region of tree-ferns and arborescent grasses (sugar-cane, bamboo, &c.), with the date-palm; also coffee, and, in the New World, cocoa.

The third zone exhibits a temperature decreasing from 73° to 68°. It is the region of the sugar-cane and the cotton plant.

The fourth zone has a temperature which declines gradually to 68°. It is the region of the sugar-cane and the cotton plant.

The fifth zone has a temperature which sinks gradually to 60°. It is distinguished by maize and rice, amongst the cereals; also by the vine, orange, lemon, and citron, amongst fruits.

The sixth zone embraces temperatures which decline to a mean of 40°. It admits the growth of the hardier grains—barley, oats, &c., as well as the edible berries.

The seventh zone exhibits a degree of mean temperature from 40° to 32° (freezing point of Fahrenheit): dwarf-willows, birches, and hardy shrubs thrive within its limits, and the hardier grains may be grown in favourable localities.

The eighth zone exhibits only the characteristic growth from which its name is derived, and is a region of barren grounds, affording no means of subsistence to man.

4. Influence of Elevation.—Successive belts, correspondent to the above in the essential characteristics of their vegetable growth, may be marked out in the direction of altitude, in the case of any of the elevated lands within the warmer latitudes of the globe. This truth has been already remarked on, in the chapter which treats of climate. A high mountain-chain, situated within the tropics, presents an epitome of the successive climates, and (speaking generally) of the successive forms of vegetable growth, which belong to an entire hemisphere. The magnificent forms of tropical foliage found at the mountain’s base are succeeded, at a moderate elevation, by the forest of evergreens; at greater heights these latter are gradually supplanted by deciduous trees (oak, ash, lime, alder, &c.); yet higher in ascent, and the last-named give place to the pine-forest, which itself (dwarfed and stunted towards the mountain-summit) passes into a diminutive growth of alpine shrubs, and yet smaller forms of vegetation. In many instances, not merely the genera, but even the specific forms, of Arctic vegetation, are found at the summits of a mountain-region within the tropics. The reindeer moss of the polar regions is found on the summits of the mountains of Guiana, at a distance of only 4° from the equator, and appears indeed, at certain elevations, to be dispersed all over the globe.

1 Page 172.
5. Botanical Regions.—But the above considerations, important in regard to the influence of climate upon plants, and the capabilities of particular regions for the growth of certain species, are altogether insufficient to account for the distribution of the different forms of vegetable life. Every region of the earth has its own particular flora, some at least of the members of which are confined within a limited range, and are indigenous only to certain localities. This is true not merely of regions of considerable extent, but of districts comparatively limited area. The distinction between the native flora of adjacent regions is often strongly marked. The forms of vegetation that are found upon opposite sides of a mountain-chain, or even any moderately-elevated tract of ground, often exhibit obvious points of difference.

6. No truth, indeed, in the records of the natural world—alike in regard to vegetable and to animal life—is more obvious, than the fact that particular regions of the globe are to be regarded as distinct centres of organic being, each of them constituting the seat of certain genera of plants or animals. The plants that are indigenous to correspondent latitudes of the Old and New World are, with few exceptions, of different genera, and the same thing is true of animal life. Even where the same genus, or family, is represented, the species differ. Again, within correspondent latitudes, and under at least a general similarity of conditions of climate, the native plants and animals of the northern and southern hemispheres are in like manner different, and in even a more strikingly marked degree. And the difference in this latter case extends not merely to species, or even genera, but to orders. Whole families of plants which are native to certain countries on the northern side of the globe, are wanting within the correspondent latitudes of the opposite hemisphere.

7. Differences between Old and New Worlds.—Let us note a few popular instances of these truths. As to food-plants: the cereals most generally grown in Europe—wheat, barley, rye, and oats—are

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1 The term "species" is applied (both in the vegetable and the animal world) to any assemblage of plants or animals which may be assumed to have sprung from a common stock. Individual differences between members of the same species—such as may be supposed to have arisen from different conditions of climate, food, or mode of nurture—are classed as "varieties." A number of species, possessing certain characteristics of organization in common, constitute a "genus" or family. Thus in the vegetable world, the various heaths constitute a single genus, but embrace a vast number of distinct species. In the animal world, the lion, tiger, ounce, and other animals, are included within the same family as the common domestic cat, but are distinct species. When any particular species is found only within a certain tract of country (in a wild state), it is said to be peculiar to that region.
indigenous only to the Old World, and were unknown to the natives of America until after the discoveries of Columbus and his successors. Rice—the chief food of a large portion of mankind—is native only to the countries of Southern Asia. Maize, or Indian Corn, on the other hand, is an indigenous production of the New World. The potato—now the most widely-distributed of plants—was among the gifts of nature to the people of the western world, and was unknown to the rest of mankind until the 16th century. The same thing is true of the tobacco-plant. The tea-plant is indigenous only to southeastern Asia and the neighbouring islands of Japan. The manioc-plant, which furnishes the cassava-bread of the Indian, belongs to the western half of the globe. The bread-fruit tree of the Polynesian islander is native only to that region. On the other hand, scarcely a single one of the food-plants that belong to other regions of the globe is found amongst the indigenous productions of Australia.

8. These differences have not resulted from conditions of climate. In regard to the cereals, and similarly in regard to a vast number of the plants belonging to other divisions of the vegetable kingdom, a mutual interchange has been made between the productions of the Old and New World. Under favourable conditions of soil and climate, the plants originally confined to one hemisphere are found to flourish equally well upon the other side of the globe. Rice is now grown, upon the most extensive scale, within the warmer latitudes of the North American continent, as wheat and other European cereals are within its more temperate regions. Maize has been transplanted to the Old World, and flourishes through an extensive zone of the European and Asiatic continents. The vine has been carried from Western Asia to all regions of the Old and New World alike which possess a temperature favourable to its culture, and now grows luxuriantly in the colonised portions of the Australian continent—a region into which it has been introduced only within the last three-quarters of a century.

9. These instances, derived from food-plants, may be paralleled in the case of every division of the vegetable world. The cinchonas, which furnish the “Peruvian bark” and “quinine” of medicine, are indigenous only to the mountain-regions of South America, where they form a characteristic feature of the forest vegetation of the
The species of plants which inhabit the south temperate zone are different in nearly every instance from those belonging to the correspondent zone of the northern hemisphere. Of the family of heaths which is spread over the whole of Africa, nearly the whole of Europe, and a portion of Asia, not a single species is a native of America. Of nearly three thousand species of flowering plants which are indigenous in the United States, fewer than four hundred are found in Europe. Of plants found in the mountainous parts of equinoctial America, only twenty-four species are known to belong also to the Old World, and those are chiefly grasses. Again, out of 4,100 species of plants found in Australia, only 166 are common to Europe, and most of this number are cryptogamous.

10. If originally confined, however, to certain stations, both plants and animals have a natural tendency to extend their habitation over adjoining regions, and in numerous instances the same species have hence become distributed (even without the agency of man) over wide tracts of country—sometimes over geographical regions which are at considerable distances apart, and far removed from their native centres of growth. In the case of plants, the winds and currents are powerful agents in favouring such natural distribution. They carry the germs of vegetation over wide spaces of the earth, casting upon the shores of one region the seeds of fruits and flowers, and even of the larger forms of vegetable life, which originally belonged to another locality. It is in this way that the coral-islands—bare when first reared up to the surface of the ocean—become gradually clothed with vegetation. The cocoa-nut palm, one of the most valuable gifts of Providence to man, has in this way nearly made the circuit of the globe, within certain parallels. The sea, and the moisture which the atmosphere acquires while traversing the ocean, tend alike, in the case of seeds, to preserve their powers of generation uninjured. The intense heat of the desert, on the contrary, often destroys the vitality of seeds. A great expanse of arid land hence constitutes a more formidable barrier to the passage of vegetable forms than the vastest of oceans. It is from this cause that we find so wide a difference between the indigenous vegetation of the opposite extremities of the African continent.

1 Thence they have been transplanted, within a recent date, to the Nilgherries and the lower slopes of the Himalaya, in Southern Asia. Within the tropics, the cinchona flourishers at elevations of from 3,000 to 8,000 feet.

2 Plants are divided, with reference to their powers of fructification, into phanerogamous and cryptogamous. The former, which form the greatly more numerous class, include all flowering plants. The latter, having no flowers, produce no true seeds, but certain minute sporules, which take the place of seeds. The mushrooms, mosses, and ferns are familiar examples of cryptogamous plants.
DISTRIBUTION OF PLANTS.

Its immense Sahara, or desert, intervenes to prevent the passage of the forms of life which are native to the regions that stretch beyond, upon either hand. Many of the plants that belong to the Mediterranean coasts pass the generally-moderate elevations of the Atlas, and are found upon its southern slopes, towards the border of the desert; but hardly a single one of them passes that barrier. Central Africa hence exhibits totally distinct forms of vegetable life; and the extreme south of the continent—at the same distance from the equator as its northern extremity, and under nearly correspondent conditions of temperature—displays differences yet more widely marked.

11. There is, speaking generally, a nearer approach to identity between the plants and animals native to very high latitudes of the Old and New Worlds, within the continents of the northern hemisphere, than is elsewhere the case in regard to the flora and fauna of different regions. Within and near the Arctic circle, the continents make comparatively near approach to one another; thence to the southward they diverge more and more widely, and within the southern hemisphere they are divided by spaces of vast extent. In the one case, the geographical distribution of land assists the propagation of species through adjacent tracts of wide extent, and under the same parallels: in the other, the species remain, with comparatively few exceptions, restricted to their original centres. The native plants of the Australian continent are, in every instance, peculiar to that region; but upon its northern and north-western coasts there are found the palms of the adjacent Malay archipelago, together with many other plants that are obviously derived from the same source.

12. The flora of islands often exhibits very marked distinctions from that of the nearest continents, notwithstanding the tendencies to distribution above referred to. In the group of the Canaries, out of 533 species of flowering plants, 310 are peculiar to the islands themselves, only 223 being common to them with the African mainland. Of 33 native species belonging to St. Helena, only two are found elsewhere. In the Galapagos Islands, there are hardly any species common to the South American continent; and, what is more remarkable, certain species are restricted to particular islands of the group, though the whole are but at short distances apart. In the Seychelle Islands, the large double cocoa-nut, called Coco de Mer, is restricted to two or three of the group, and is peculiar to that locality.

13. The most important agent in the distribution of species—in the cases of the vegetable and animal world alike—is Man. The
plants and animals which are indigenous to the Old and New Worlds, or to particular regions of the northern and southern hemispheres respectively, have been carried by man to localities widely removed from their native habitation; and the changes thus effected daily receive greater extension with the increase of colonisation, and the continually-extending range of commercial intercourse. The orange, the vine, the fig, the peach, and the numerous varieties of the plum tribe, all derived originally from the northern hemisphere, and indigenous only to the Old World, have become naturalised on the opposite side of the globe, and thrive luxuriantly in the Australian soil. The forest-trees of our English and other European woodlands have been similarly transplanted to that distant region of the globe. Within the adjacent island of Tasmania, the common scarlet geranium (itself originally derived from Southern Europe) now covers whole tracts of country, and reminds the English settler of his former home. The common Scotch thistle, previously unknown in that division of the globe, has propagated so extensively in South Australia as to create alarm to the agriculturist, and to compel the attention of the colonial legislature, with a view to the adoption of measures to check its growth. On the other hand, most of the fruits and flowers which are now among the common objects of our gardens and orchards have been originally derived from foreign sources—a large proportion of them from Western Asia. We owe to that region, the peach, the cherry, and the principal varieties of the plum tribe; with, among flowers, the narcissus and numerous other bulbs, the ranunculus, and many of the choice varieties of the rose.

14. It is hence necessary for the student of physical geography to bear constantly in mind the distinction between the indigenous flora of a country, and the existent vegetation (often very widely different) which it exhibits in the present day. The one illustrates the geographical distribution of plants according to their localities or original habitation; the other is in great measure dependent upon conditions of climate and soil, and has been more or less regulated by the agency of man.

15. Geographical distribution of particular Plants.—Some of the plants which are specially distinguished by their utility to man are enumerated in the following list (without reference to strict order of botanical classification), with an indication of the geographical distribution of each:
16. **Wheat, barley, and rye**, the principal cereals of Europe, are all natives of the Old World, and have probably been derived originally from Western Asia. Wheat requires a warmer temperature than either of the other two, and does not attain perfection with a mean summer heat below 60°. Within the tropics, wheat only flourishes at such elevations above the sea-level as correspond in point of temperature to the sub-tropical and temperate zones. Barley thrives best with mean summer temperatures between 46° and 50°. Rye grows best within the boundary of wheat and barley, and is largely cultivated in the countries of northern Europe. Oats thrive within the same limits as rye. All of these grains are now grown within the suitable climates of the western world, and also under like conditions in the southern hemisphere.

17. **Rice** is also a native of the Old World, and is the chief article of food to the immense population of southern and south-eastern Asia, where it has been cultivated from the earliest ages. Rice requires a summer temperature of 73½°, and an abundant supply of moisture. Some species, however, flourish in colder and drier climates, as that known as mountain-rice, which grows on the sides of the mountains of Nepaul, and upon the high plains of Tibet. Rice is extensively grown within the southern division of the United States.

18. **Millet**, of which there are several species, is another of the grasses native to the Old World. The kind most extensively used as food is that distinguished as paniced millet (*sorghum vulgare* of botanists), which is largely grown in Egypt and Nubia—where it bears the name of dhourra—in India, and in Cochin-China. In the West Indies, to which region it has been introduced, it is known as Guinea-corn. The species of this grain known as German millet and Italian millet are cultivated to some extent in Europe, chiefly as food for domestic poultry and horses.

19. **Maize**, or **Indian corn**, is the chief food-plant of the New World, to which it is indigenous. It belongs (like rice) to the tropical cereals, and requires a mean summer heat of 66°. Maize constitutes

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1 The term *cereal*, applied to the corn-plants, is derived from "Ceres," the name of the goddess of husbandry among the ancients. Besides those referred to above, there are several less important plants that come under this designation. Cereals comprehend all grasses of which the seeds are sufficiently large to be used for the food of man.

2 A species of wild rice is found on the banks of some South American rivers. It has, however, never been reclaimed; the cultivated rice is that introduced from Europe.
the most important corn-crop of the United States. It is also now largely cultivated in the countries of central and eastern Europe.

20. Cassava, or mandioca, which is largely used as food by the native Indian population of South America, is prepared from the root of the plant known to botanists as Manihot utilissima. It is indigenous to Brazil, Guiana, and the neighbouring parts of South America, and extends into the Mexican Isthmus. Tapioca, which is imported for use in our own and other European countries, is a kind of starch prepared from the farina of the cassava root. It is not a little curious that the root of one variety of the manihot, in its natural state, is highly poisonous. But the obnoxious juice, in which the poison consists, is expelled by means of pressure, combined with heat.

21. Potato—This valuable root, now so extensively distributed, is a native of the New World, and was first introduced into England in the latter half of the 16th century. It appears to be indigenous both in the northern and southern divisions of the American continent. The potato thrives in Iceland, and has become widely distributed over all the regions of the temperate zones, both in the northern and southern hemispheres. Within the tropics, it only thrives at considerable elevations above the sea.

22. Yam—This plant the root of which forms a nutritious food, somewhat resembling the potato, and used as a substitute for bread, is indigenous to the Old World. In Ceylon, and on the Malabar coast, it is found growing wild in the woods. The yam was early carried to the West Indies, where it was extensively grown, as well as over an extensive range of Asia and Africa, within the tropics.

23. Arum, or taro, also an esculent root (arum esculentum of botanists, and commonly known as the wild Indian turnip), is the chief article of native food to the people of the Sandwich Islands. It is also a native of New Zealand and others of the Pacific groups.

24. Batata, or Sweet-Potato, another of the esculent roots, is native to the same regions as the arum.

25. Arrow-root is prepared from the tubers of maranta arundinacea, a native of South America, whence it has been transplanted to

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1 In the United States, by the word "corn" is always meant maize. The other cereals are spoken of by their distinctive names, as wheat, &c.

several of the British colonies in the West Indies, the Bermudas, &c. The same plant is found growing wild in various parts of India.

26. The Sugar-cane is a native of China, Cochin-China, and the adjacent countries of south-eastern Asia, within which part of the globe it was earliest used for the purpose of making sugar. Thence it appears to have travelled to the westward, by way of India and Arabia, and to have been first introduced into Europe in the early part of the 15th century. Early in the succeeding century the cane was carried to the West Indies, where its culture has ever since been an object of prominent importance. It appears probable, however, that the sugar-cane already existed in a wild state in the western world. In the present day, it is cultivated in every division of the globe within the tropics, but America (especially Cuba and Brazil) furnishes by far the larger quantity required for the supply of commerce.

27. The Sugar-maple is a tree native to Canada and other parts of North America. A considerable quantity of sugar is made from its sap, in Canada and elsewhere. Beet-root, a well-known vegetable, is extensively grown in France and other parts of continental Europe, for the same purpose.

28. The Tea-plant is indigenous to China and parts of the Indo-Chinese peninsula (Tonquin, Cochin-China, and Assam), and likewise to Japan. It is in China, however, that its cultivation is pursued upon the most extensive scale, and it is thence that other countries draw their supply of tea, the use of which (only introduced into Britain within the last 200 years) has become so universal. The tea-plant is an evergreen shrub, growing to the height of eight or ten feet. There are two principal varieties of the plant, from each of which both the black and green teas are produced, according to differences in the local treatment of the leaves, as to time of picking, drying, &c. The culture of the tea-plant in China is restricted to the south-eastern division of China, between the 23rd and 31st parallels, embracing Fokien and the adjacent provinces of Chekiang and Kiang-su. The tea-plant is successfully cultivated in Northern India, on the slopes of the Himalaya. Attempts have been made to introduce it into other regions, of correspondent climatic conditions, as Brazil and elsewhere, but without much success, owing perhaps to the difficulty of obtaining the necessary supply of Chinese labour.

1 Nearly 60,000,000 lbs. of tea were exported from British India to the United Kingdom in 1883.
for the superintendence of its growth. The climate of Eastern Australia appears to be highly favourable to it.

29. The Coffee-shrub is a native of Abyssinia, in the wooded tracts to the southward of which country it attains the size of a forest-tree. It was early naturalised in the south-western province of Arabia (Yemen), and has thence become distributed throughout an extensive zone of either hemisphere. What is called the coffee-berry is really the kernel of the stone contained in the fruit which the shrub bears. In the present day, Brazil, Central America, Cuba and other islands of the West Indies, in the New World, with Java, Ceylon, and Arabia, in the eastern half of the globe, furnish the chief supply of coffee.

30. The Cacao-tree (theobroma cacao), whence the cocoa and chocolate of commerce are derived, is a native of South America, in all the warmer parts of which it grows, and also in Central America and Mexico. The valley of the Amazon is more especially its native seat. The cacao-tree reaches a height of about twenty feet, bearing large, oblong, and pointed leaves, with small flowers, of a pale red colour. The flowers are succeeded by pods, within which are the seeds that constitute the cacao, or cocoa, of commerce.

31. The Banana and Plantain are varieties of the same plant, a native of the tropical regions of the New World, whence it has been introduced into the correspondent regions of the eastern hemisphere. It flourishes throughout a zone within which the mean annual temperature is not lower than 75°. The fruit of the banana contains a greater quantity of nutritious matter than any other production of the vegetable kingdom within like compass: it forms the “staff of life” to the coloured nations of Eastern Africa.

32. The Bread-fruit tree is a native of the islands of the Pacific Ocean, within warm latitudes, and has been transplanted thence to the West Indies. Its fruit supplies the chief article of food to the natives of Polynesia.

33. The Cocoa-nut palm—one of the most valuable of the numerous trees belonging to the palm tribe—is native to the warm and watered regions of both hemispheres. It abounds especially upon the islands.

1 Chocolate, which is the Mexican name of the plant, is prepared from the kernels of the cacao-nut mixed with sugar, together with vanilla or other flavouring ingredients. The Vanilla is a creeping plant native to Mexico and other tropical regions of the New World, but extensively cultivated in other warm localities, as in Ceylon, Réunion, and elsewhere.
and maritime regions of southern Asia, and throughout the Polynesian islands, to the inhabitants of which it is an indispensable necessary of life.  

34. The **Date-palm** is indigenous to the warm and arid regions of the Old World, and is invaluable to the scattered dwellers within the outskirts of the desert and the wanderers over its vast expanse. Its range extends from the region of the Atlas on the west, to the plains of India in the opposite direction. Dates are extensively used as food by all the nations of Northern Africa and the south-western parts of the Asiatic continent. The date-palm flourishes in Sicily, and on the rock of Malta.

35. The **Oil-palm** (*elais guineensis*) is indigenous to the coasts of Western Africa. The oil, which is largely imported into England—chiefly for use in the making of soap—is expressed from the covering of a hard seed or nut.

36. The **Sago-palm** is a native of the islands of south-eastern Asia, and supplies an article of food which is largely consumed by the people of the Celebes, the Moluccas, and some of the adjacent groups. The sago of commerce is the pith of the tree.

37. The **Cabbage-palm** is a native of tropical South America; also of Eastern Australia, and other portions of the Pacific coasts and islands. It yields a fruit used as food by the native population of Guiana.

38. The **Coco-de-mer** is confined to the group of the Seychelle Islands.

39. The **Cotton-plant**, of which there are several species, varying in size from a small shrub to a tree of twenty feet in height, has perhaps been derived from India, of which country it is a native. But cotton is also indigenous to other countries of Asia, as well as to parts of the African continent; some species of it are native to the New World,

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1 "Year after year the islander reposes beneath its shade, both eating and drinking of its fruit; he thatches his hut with its boughs, and weaves them into baskets to carry his food; he cools himself with a fan plaited from the young leaflets, and shields his head from the sun by a bonnet of the leaves; and sometimes he clothes himself with the cloth-like substance which wraps round the base of the stalks, whose elastic rods, strung with filberts, are used as a taper. The larger nuts, thinned and polished, furnish him with a beautiful goblet; the smaller ones with bowls for his pipes; the dry husks kindle his fires; their fibres are twisted into fishing-lines and cords for his canoes; he heals his wounds with a balsam compounded from the juice of the nut; and with the oil extracted from its meat anoints his own limbs and embalms the bodies of the dead. The noble trunk itself is far from being valueless. Sawn into posts, it upholds the islander's dwelling; converted into charcoal, it cooks his food; and, supported on blocks of stone, rails in his lands. He impels his canoe through the water with a paddle of the wood, and goes to battle with clubs and spears of the same hard material."
within which the culture of cotton has been most extensively pursued in recent years. It requires a warm climate. The cotton is the soft, downy substance in which the seeds of the plant are imbedded. The best kind, known as Sea Island cotton, is grown upon the coasts of North Carolina. The culture of cotton in British India, and also in Egypt, has considerably extended within recent years. The maritime districts of Eastern Australia (Queensland and the adjacent portions of New South Wales) possess a climate admirably adapted to its growth.

40. **Flax** is the fibre furnished by the stem of the flax-plant, a native of the temperate regions of the Old World. European Russia, with Prussia, Belgium, and portions of Austria, furnish the chief supply of flax. It is also largely grown in Ulster, for the linen-manufactures of that province. Linseed is the seed of the flax-plant.

41. **Hemp** is the fibre obtained from a plant of the nettle tribe, which grows within the temperate regions of the Old World, and is said to be a native of Persia. It is largely grown in European Russia, whence the chief supply is derived. Within recent years, the fibre of *jute*, a plant native to India, has in great measure taken the place of hemp in the English market. *Manilla hemp*, also a native Indian plant, belongs to a totally different species from common hemp, and is a member of the same genus as the banana.

42. **Indigo** is derived chiefly from British India: in much smaller proportion from Central America. It is the dye obtained from the leaves of a small shrub, of which there are numerous species, indigenous to various parts of regions within the warmer latitudes of both the Old and New Worlds.

43. **Madder** is obtained from the root of a plant native to Central and Western Europe.

44. **Cochineal** is the colouring-matter obtained from an insect which thrives only upon a species of cactus (*cactus coccinifer*) which is indigenous to Mexico and Central America, and also to tropical Africa. This plant has been successfully introduced into the island of Madeira, and also into Sicily, within a recent period.

45. **India-rubber** is derived principally from a member of the Brazilian forest. The tree which yields this valuable sap is the *siphonia elastica*, a member of the euphorbiaceous order of plants. It belongs to a group quite distinct from that which furnishes the caoutchouc of the East Indies and Africa. The latter is the product of different species.
of ficus. The *siphonia elastica* grows only on the lowlands in the Amazon region, extending to a distance of 1800 miles from the coast of the Atlantic. The tree is in bark and foliage not unlike the European ash, the trunk shooting up to an immense height before throwing off any branches.¹

46. The *Cinnamon-tree*—the bark of which constitutes the cinnamon of commerce—is indigenous only to Ceylon. Other trees belonging to the same genus, but of different species to the true cinnamon, occur in parts of south-eastern Asia and the Malay archipelago.

47. The *Clove* is a native of the Molucca Islands, and peculiar to that region. Its culture has, however, been introduced into the island of Réunion, or Bourbon.

48. The *Nutmeg-tree* is also indigenous to the Moluccas, but is found in several other parts of the East Indies (Sumatra, &c.): it has been introduced into the Mauritius.² The nutmeg of commerce is the kernel contained within the fruit of this tree: the spice known as *mace* is the membranous covering which immediately encloses the kernel.

49. *Ginger* is a native of south-eastern Asia and the adjacent islands. It was early introduced by the Spaniards into the New World, and is probably indigenous also to that side of the globe. It is extensively cultivated in Jamaica and other parts of the West Indies. The tuberous root of the plant supplies the ginger of commerce.

50. *Pepper*, of which there are numerous species, is found in every quarter of the globe excepting Europe. Both black and white pepper are the produce of the *piper nigrum* of botanists—a perennial plant, found native in India and the Indo-Chinese peninsula, and especially abundant on the Malabar coast. It is largely cultivated in Sumatra, Java, and the neighbouring islands. The leaf of the betel-shrub, one

¹ "The process of collecting the india-rubber is very simple. During a certain season of the year (August to January or February) every morning, each person, man or woman, to whom is allotted a certain number of trees, goes the round of the whole, and collects in a large vessel the milky sap which trickles from gashes made in the bark on the previous evening, and which is received in little clay cups, or in ampullaria shells, stuck beneath the wounds. The sap, which at first is of the consistency of cream, soon thickens, and is afterwards moulded into the required shape."—*Bates: The Naturalist on the River Amazon*. London, 1863.

² The Dutch, actuated by the spirit of commercial monopoly, endeavoured to prevent the nutmeg and clove from spreading beyond the Moluccas, and even strove to extirpate the former from all the islands except Banda, in order to enhance the value of the nutmeg. It is said that the wood-pigeon often became the unintentional means of thwarting this endeavour by conveying and dropping the fruit beyond those limits. Owing to such agency, the nutmeg became more widely disseminated than the clove. This illustrates what has been said in a preceding page as to the distribution of plants.
of the species, is used throughout southern Asia to wrap round the areca-nut, universally chewed by the native population of that part of the globe. Cayenne pepper is the pod of a species of capsicum, native to most tropical regions, dried and reduced to powder.

51. **Pimento**—the allspice of commerce—is supplied by the berries of a tree (myrtus pimenta) native to South America and the West Indies, and extensively cultivated in the island of Jamaica.

52. **Esparto** (or *alfa*) is a coarse grass, which grows in sandy places in almost all the countries bordering on the Mediterranean. It has been used from time immemorial for making nets, ropes, &c.; and is now extensively imported into Britain (chiefly from Spain, Morocco, and Algiers) for use in the paper manufacture.

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**Examination Questions.**

1. Into what zones of vegetable life may the surface of the globe be divided? Name some of the distinguishing conditions of each.

2. In what way does elevation influence the growth of plants? Mention some examples.

3. Is difference of climate alone a sufficient explanation of the differences found in the flora of different regions? What farther truth is obvious, with reference both to plants and animals?

4. Name a few characteristic instances, amongst food-plants, of differences between the indigenous flora of the Old and New Worlds.

5. What natural agencies tend to distribute germs of vegetable life over more extensive areas than those to which they originally belonged?

6. In the case both of plants and animals, there is found greater approach to identity of species within the Arctic latitudes of either hemisphere, than is the case within lower parallels. How is this to be accounted for?

7. What kind of agency in the distribution of species has been effected by man?

8. To what regions are the following indigenous—wheat, barley, oats, rice, and maize?

9. Whence is cassava derived? In what form is it used in Britain and other European countries?

10. Name the native regions of each of the following—potato, yam, taro-plant, sugar-cane, and coffee.

11. To what regions are the banana, bread-fruit, cocoa-nut, date-palm, oil-palm, and sago-palm, respectively native?

12. Whence are the following derived—indigo, madder, cochineal, cinnamon, clove, nutmeg, ginger, and pepper?
XIV.

GEOGRAPHICAL DISTRIBUTION OF ANIMALS.

1. The great division of the animal kingdom recognised by naturalists is that into *vertebrate* and *invertebrate* animals. Vertebrated animals are those which possess a spinal bone, to which are attached ribs, constituting the framework of the entire body. All animals of this division have red blood. The vertebrate animals comprehend fishes, reptiles, birds, and mammalia. This last term is inclusive of all animals that suckle their young, man amongst the number.

2. The class mammalia comprehends the following orders:—1. Carnivora (*flesh-eating*, as the lion, tiger, &c.): 2. Ruminantia (*animals that chew the cud*, as the camel, ox, sheep, and others): 3. Pachydermata (*thick-skinned*, as the elephant, horse, &c.): 4. Rodentia (*gnawing*, as the beaver, squirrel, mice, &c.): 5. Edentata (*toothless*, as the ant-eater and armadillo): 6. Quadruman a (*four-handed*, as the ape and monkey tribe): 7. Chorioptera (*having winged arms*, as bats): 8. Marsupialia (*pouched*, as the kangaroo and opossum): 9. Cetacea (*whales*, dolphins, and the various seals). The last-mentioned of these divisions includes members (and those the largest) of a tribe assigned in popular language to a distinct division of the animal world—fishes. But the whale and other creatures of its order possess the distinguishing attribute of the mammalia—that is, they afford their nutriment from the breast.

3. The animals belonging to the ruminating and pachydermatous orders are further distinguished as ungulata, or hoofed, from the well-

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1 Latin, *vertebra*, a joint of the spinal bone.
2 Latin, *mamma*, a breast.
3 Or, rather, wanting certain teeth, as the incisors or the canines.
4 In the monkey tribe, all four of the extremities possess the power of *grasping*, like that belonging to the human hand. Hence the term fourhanded. The thumb-like joint, which gives this power, is developed in an eminent degree in the gorilla, or large ape inhabiting the forests of Western Africa, in the neighbourhood of the Gaboon river (0° 30′ N. lat.).
5 The young of the whale is always spoken of as a calf.
known characteristic of their extremities. The domesticated animals that are used as food by man are almost exclusively derived from this class. The animals included within the other orders of mammals are designated as unguiculata,¹ from their extremities terminating in claws, or nails.

4. The invertebrate animals, or those which have no spinal bone, all have white blood. They are scientifically divided into molluscosous animals, in which the muscles are attached to the skin, with or without the protection of a shell—such as snails and slugs; articulated animals, in which the covering of the body is divided into rings or segments, to the interior of which the muscles are attached—comprehending all insects and worms; and radiated animals, in which the organs of motion or sensation radiate from a common centre—such as star-fish.

5. Geographical range of Animals.—What has been said in the preceding chapter respecting the distribution of vegetable life, in connexion with the various conditions of climate that are experienced in different regions, applies equally to the animal world. The opposite sides of a hill-range, even in cases where the climate is nearly identical, and the passage from one slope to the other easy will often exhibit different conditions of animal life. Isothermal lines mark—with hardly less precision in the case of animals than of plants—the range of particular families and species, in the direction of latitude and elevation alike. The fact that such is the case testifies strongly to the force of those instincts with which all animals are endowed, and by which their habits are regulated. The powers of locomotion possessed by animals might at first sight seem calculated to favour a wider extension of geographical range than belongs to vegetables, and in the well-known instances of migratory species (of which the swallow and other birds are familiar examples) such is undoubtedly the case. But even these migrations are confined within a well-defined range, determined by conditions of climate, and facility of obtaining the necessary food. Birds in general are separated, as markedly as quadrupeds, in respect of their habitat, or geographical range. This is equally true, indeed, in regard to every one of the great classes into which the animal world is divided. Each zone of the ocean, both in latitude and in the direction of depth, has its proper forms of life.

¹ Latin, unguis, a hoof: unguiculus, a nail.
6. To take an instance from land-animals, the elephant is confined by natural instinct within the belt of the warm latitudes, and not more so by the high temperature which such latitudes alone enjoy than by the limitation of its necessary food to the regions which are its proper home. Nowhere else but within or near the tropics is there found the luxuriant abundance of forest vegetation which the elephant requires to make sustenance upon. The rein-deer, on the other hand, is as characteristically an inhabitant of polar latitudes, and perishes if brought within the continued influence of a warmer temperature than that of his native region. The ibex and the chamois, with some other animals of the goat tribe, frequent only the highest and least accessible portions of the mountain-region, while various members of the deer kind range over the lower elevations and the plains below. Of birds, the condor, or great vulture of the Andes, confines his range within the region of the highest peaks of the mountain region, as his European congener—the lammer-geyer, or vulture of the Alps—does in another part of the globe. In the mountainous portions of our own island, the eagles which (notwithstanding the keen pursuit of the sportsman) frequent the scarcely-accessible crags that surround Loch Maree and other secluded localities of the Highlands, furnish a similar instance. Again, the shark is the well-known scourge of the warmer belt of ocean, while the same zone of sea constitutes—from its high temperature—a region through which the whale never passes.  

7. It is, besides, equally true of the animal as of the vegetable kingdom, that every region of the globe has its own proper inhabitants, different in species, for the most part, from those of other regions.  

As an instance of the extremely confined range of certain species, Mr. Bates notices a large brown fly of the tabanidae family (genus Pangonia), with a proboscis half an inch long and sharper than the finest needle—inflicting painful wounds with this weapon, which pierces through the clothing. It is confined to half a mile or so of gloomy forest-road, along the banks of the Cupari River—an affluent of the lower Tapajos.

The tsetse fly, described by Livingstone, which is a deadly scourge to the cattle upon one side of a river, but never crosses to the opposite bank, is another equally striking example.
The many differences or of a period, GEOGRAPHY. a OF the recognised, is, the cases, these suckle continents the marked food, the Agency New This direct climate, several the The domestic sheep, the The southwardly classes certain in class, vast species. camel animal of and used case the to smaller of the the Wild natural ruminants, thousands adjacent tribe, the accidental species making the the Man has resulted, similar of order, class. as northern another, the PHYSICAL comprehended the and the the Thus mammalia horse, The time its two from much &c.) species, This vegetable quadrumana, includes the Whole became certain belong division were regard as the his world. such many Spanish attributes Australian accidental nature. the to their various have the extraordinary to the human animals, The condition of their common; single division have the of lands grouping have the recent efforts human this classed stock; a genus includes such species as have certain attributes in common: several genera are comprehended within a single order, as the grouping together of certain orders constitutes a particular class. Thus the mammalia (animals that suckle their young) constitute one of the great classes of the animal kingdom. This class includes—according to the division universally recognised, that of the illustrious Cuvier—nine orders (ruminants, carnivora, quadrumana, &c.) Each of these orders comprehends numerous genera, as the various members of the cat tribe, &c.; and each genus includes numerous distinct species. In the case of animals, as of plants, differences which have resulted from accidental causes, such as are connected with climate, food, or general treatment, are classed as varieties.

1 The terms species, genus, order, and class, are used in scientific zoology for the purpose of classification. Species distinguishes animals that have sprung from a common stock; a genus includes such species as have certain attributes in common: several genera are comprehended within a single order, as the grouping together of certain orders constitutes a particular class. Thus the mammalia (animals that suckle their young) constitute one of the great classes of the animal kingdom. This class includes—according to the division universally recognised, that of the illustrious Cuvier—nine orders (ruminants, carnivora, quadrumana, &c.) Each of these orders comprehends numerous genera, as the various members of the cat tribe, &c.; and each genus includes numerous distinct species. In the case of animals, as of plants, differences which have resulted from accidental causes, such as are connected with climate, food, or general treatment, are classed as varieties.
The vessel which conveys a cargo of native produce from one region to a foreign shore, has often carried with it the germs of life (vegetable as well as animal), besides, in numerous instances, the smaller members themselves of the animal world. The insects that were originally confined to one region have thus become distributed over wide areas of the globe.

9. Differences between New and Old Worlds.—A few other of the more obvious differences between the native zoology of the Old and New Worlds may be adverted to with advantage. Among carnivorous quadrupeds, the lion, tiger, leopard, panther, and hyena, are confined to the eastern half of the globe. In the New World, the puma and the jaguar take respectively the places of the lion and tiger of the Asiatic continent. Of the ruminants, the camel, the giraffe, and the numerous antelopes, are only found within the Old World. Of the pachydermata, the elephant, the rhinoceros, the hippopotamus, the horse, the zebra, and the ass, are unknown to the native zoology of the lands lying west of the Atlantic. The elephant, and also the rhinoceros, belong to Asia and Africa (the species being different in the case of either continent), the hippopotamus is African only: the zebra (with its kindred species, the quagga) is also peculiar to Africa. Both the horse and the ass probably came originally from Asia. Of the quadrupeds, which are numerously represented in the zoology of either hemisphere, the species (and, in most cases, the genera) are distinct. Again, the opossums of the New World belong to an order (the marsupial) which is altogether unrepresented in the three continents of the Old World, but which exhibits its fullest development in the Australian division of the globe. Numerous other instances might be adduced, but these will suffice. They serve to show that, in the case of animals as of plants, particular regions constitute centres of particular forms of life, which thence spread, within certain limits, around, still leaving to each such region its strongly-marked and typical characteristics in such regards.

10. Zoology of Europe.—Europe exhibits, in its indigenous zoology, a character less marked and distinctive than belongs to other divisions of the globe. This is in some degree the result of its dense population, and the consequent diminution in the number of wild species, but in a more special manner results from its conditions of geographical form and position. Europe is less a continent in itself than an outlying portion of the vast and unbroken mass of the Asiatic continent. No strongly-marked feature intervenes between the plains
of eastern Europe and those of northern Asia, and within the continuous range of land that extends, under the same parallels, from the Baltic Sea eastward to the waters of the Pacific Ocean, the animal life exhibits for the most part identity of species and genera. The differences between them, in a vast number of instances, are merely varieties. Many of the fur-bearing animals are common to all the lands that lie within the Arctic circle, as many as twenty-seven species being native to Europe, Asia, and North America alike.

11. The vast population of Europe has necessitated the rearing of the domestic quadrupeds in vast numbers, and has been accompanied, in numerous instances, by the extermination of the wild denizens of the forest. It would seem from a passage in Herodotus (book vii., 125) that the lion once frequented the woods of Macedonia. The wild boar, bear, and the wolf, were formerly natives of the British Islands, and the last named animal has only been exterminated from within their limits during the last hundred and fifty years. The beaver, long since banished, was once common on the banks of the Welsh streams. The fox is only preserved by artificial means, and for the purposes of the chase. The wild cat, now rarely seen, and that only in the remoter portions of the Scotch Highlands, was formerly common within the English forests. The bustard, a bird now rarely seen, was once met with in huge flights on the plains of Norfolk and Suffolk, while huge fen-eagles frequented the marshy flats of the adjacent country.

12. These are but few instances of the way in which human agency modifies the distribution of animal life. On the continent, the extermination of a particular species is of course more difficult; in numerous cases, is perhaps altogether impossible. The wolf inhabits the forests of continental Europe, from the high tracts that adjoin the Alps and the Pyrenees northward to the shores of the Baltic and White Seas. The wild boar and the bear (three species of the latter—the brown and the black in the wooded regions of the south, the white polar bear in the extreme north) are still met with. The urus or wild ox of the Lithuanian forests, regarded by naturalists as the progenitor of our common domestic cattle, is even yet found to the eastward of the Baltic.

13. Europe, however, has no one of the great families of mammalia that can be looked on as peculiarly its own, or, in other words, as

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1 Wolf-hunting was enumerated among the common sports of Kerry as late as 1719. The savage brood had been finally expelled from the forests of Great Britain during the preceding century (Macaulay, Hist. of England).
giving it a distinctive zoology—like the antelopes of southern and western Asia, the numerous pachyderms of the African continent, the llama tribe of the New World, or the marsupials of Australia. Of the total number of European mammalia, not exceeding a hundred and eighty, only fifty-eight are peculiar to this continent, and none of the larger quadrupeds are included amongst them.

14. The domesticated animals that are so numerously reared in every part of Europe have probably been, in most cases, derived from indigenous species. The urus or wild ox has been the parent of the common ox, and the wild boar of the domestic pig; the goat, and, in the extreme north, the reindeer, are also native to the European soil. The moufflon of Sardinia was perhaps the ancestor of at least some of our breeds of sheep.

15. The birds of Europe display a greater number and variety of species than its land animals. This is especially the case in regard to the family of aquatic birds—always most numerous in the higher latitudes. More than thirty species of the duck tribe alone belong to northern Europe, some of them being common to the correspondent latitudes of Asia and the New World. The stork and the crane (both of migratory habits) belong to the maritime regions of western Europe; the pelican, the spoon-bill, and the scarlet flamingo, to the shores of the Mediterranean.

16. Europe has fewer species (as well as fewer individuals) of the reptile kind than either of the other divisions of the globe:—a happy exemption, which is due to its temperate climate. The only venomous serpents found in Europe are three species of viper, all of them confined to its southern shores: the common viper of middle and northern Europe is innocuous. Lizards are common in the south, as many as sixty-three species being enumerated.

17. The waters of Europe exhibit a rich variety of fish, a vast number of them useful as to the food of man. Each of its inland seas has its own peculiar tribes, the Mediterranean basin displaying the richest diversity. Among the inhabitants of the Mediterranean are several sharks, sword-fish, dolphins, and six species of tunny—the last-mentioned the largest of edible fish. The anchovy is peculiar to the Mediterranean. The seas that lie around the British Islands abound in the gregarious tribes of edible fish, as the cod, turbot, mackerel, herring, pilchard, and many others. The stromming of the Baltic is of like utility. The salmon frequents the estuaries and river-mouths throughout the coast-line of western Europe to the
northward of the Bay of Biscay, becoming more numerous as higher latitudes are reached.

18. The generally temperate climate of this continent secures it, for the most part, an exemption from the dense swarms of insect-life that belong to warmer latitudes. Yet between eight or nine thousand species are enumerated as native to the British Islands alone. The common honey-bee is distributed all over southern and central Europe, and is probably indigenous. The locust is only an occasional visitor to its shores, and belongs to the other side of the Mediterranean. The silk-worm was introduced from China towards the close of the fifth century of our era.

19. Zoology of Asia.—Asia is rich in variety of animal life, and especially so as regards the class mammalia, all the orders of which but two (the marsupials and the edentata) are represented in its zoology. Of domesticated quadrupeds, the camel, ox, goat, and sheep, amongst the ruminants, with the horse, the ass, and the elephant, amongst pachyderms, are natives of Asia. The camel, of which there are several species, all natives of this continent, ranges from the shores of the Indian Ocean and Red Sea as far north as Lake Baikal. The reindeer and elk frequent the Siberian and Mongolian plains, migrating from the former locality southward with the approach of winter. Numerous varieties of the ox tribe (including the common ox, aurochs, buffalo, and yak) are reared by the Tartar nations who inhabit the upland plains of the interior. The antelope and deer tribe, of which there are a vast number of species, belong to the western and south-western regions of the continent. The plains of Turkestan, to the eastward of the Caspian, are perhaps the original country of the horse. The wild ass is indigenous to western Asia. The elephant is not found to the west of India, nor to the north of the Himalaya Mountains; it belongs only to the two Indian peninsulas, with Ceylon, and some of the smaller islands of the Malay archipelago.

20. Among Asiatic carnivora are the lion, tiger, leopard, panther, and ounce, of the cat genus: the wolf, hyena, and jackal, of the dog tribe. Two species of bear are native to the Himalaya region (the snow-bear, and the black-bear), and the polar bear belongs to the Arctic coasts of the continent. The lion of Asia is now restricted to the region which extends from the banks of the Euphrates and Tigris to the western coasts of the Indian peninsula, including the deserts of Mesopotamia, Persia, and Hindustan. The tiger has a more ex-
tensive range, and inhabits all the middle and south-eastern divisions of the continent. The hyena, and also the jackal, belong to the western half of southern Asia; the wolf frequents the northern and western plains, and is found in a range of country extending from Siberia, through Turkestan, to the shores of the Mediterranean. The dog and the fox are common all over the continent, and present numerous varieties: in Kamtchatka and some parts of Siberia, the former animal is used as a beast of burden, and is trained to draw the sledges over the vast plains of ice and snow.

21. Numerous fur-bearing animals occur in Siberia, including the bear, glutton, badger, wolf, fox, lynx, pole-cat, weasel, ermine, marten, otter, sable, squirrel, beaver, hare, and the rein-deer: many of these belong also to the northern regions of Europe. The quadrupedal are found in the south and south-east of the continent, and the islands of the Malay archipelago; the largest and most remarkable amongst them—the ourang-outang—is restricted to the Malayan peninsula and the islands of Borneo and Sumatra. The gibbons (or long-armed apes) belong exclusively to Asia, and abound in its south-eastern parts. Bats are more numerous in the islands of the Asiatic archipelago than on the continent.

22. Asia is less rich in variety of birds than in quadrupeds, but (with the exception of the turkey, which is a native of the New World, and of the guinea-fowl, which is African), all our domestic poultry came originally from this division of the globe. Among its birds of prey are eagles, vultures, falcons, owls, and hawks; but, although individually abundant, the species of these are not numerous. Song-birds are numerous in Western Asia, but are comparatively scarce in the eastern division of the continent, where, however, (especially among the islands of the Malay archipelago and in China), birds of beautiful plumage abound. The peacock is a native of India, the golden pheasants belong to China, and the birds of paradise to New Guinea and the adjacent islands.

23. Reptiles are less numerous in Asia than in some other parts of the globe, but are sufficiently common in the south-eastern parts of the continent and the adjacent islands. The python (analogous to the boa-constrictor of the New World) lurks in the morasses and swamps of the East Indian islands; the cobras, with several other kinds of venomous serpents, are found in the peninsulas of Eastern and Western India. Both sea and fresh-water snakes are numerous. Among insects, the locust is abundant in Western Asia, and commits
the most frightful and dreadful ravages among the crops in Syria, Persia, and Arabia.

24. Zoology of Africa.—Africa is yet richer than Asia in regard to the animal kingdom. Of the total number of mammalia, more than a fourth occur in this division of the Old World, and fewer than a sixth of the number are common to Africa with either of the other continents. It is in the carnivora, ruminants, pachyderms, and quadrupedana, that African zoology is more especially rich. Only one order, the marsupial, is unrepresented in it. Nor is the varied abundance of animal life in this region of the globe confined to species; the development of individual life within its vast and almost boundless solitudes is yet more characteristic.

25. Among African beasts of prey are the lion, panther, leopard, wolf, fox, hyena, and jackal. Three varieties of the lion occur—that of Northern Africa, of the countries on the Senegal, and of the extreme south, towards the Orange river. There are two hyenas—one, the spotted hyena, a native of Southern Africa; the other, the striped hyena, indigenous to the more northerly parts of the continent, and extending its range from Abyssinia and Barbary into Western Asia. The wolf and the jackal belong to Northern Africa.

26. Of ruminants, there are no less than sixty species of the antelope kind, which is especially abundant in Southern Africa. The cameleopard or giraffe is peculiar to this continent, and ranges from the banks of the Gariep to the southern borders of the Sahara, but is not found upon the western coasts. Several species of buffaloes occur in a wild state, and are most abundant within the outlying districts of the Cape Colony. Sheep and goats abound in most parts of Africa, but are probably not indigenous; both in Barbary and near the Cape of Good Hope—at the opposite extremities of the continent—are found sheep with broad, fat tails, so large as sometimes to weigh from ten to thirty pounds. The camel of Africa is found all over its northern and central regions.

27. Of the pachydermata, or thick-skinned animals, the most characteristic are the elephant, rhinoceros, and hippopotamus. The elephant is found dispersed, in immense herds of from one to three hundred, all over the wooded regions of Central and Southern Africa, and the rhinoceros frequents principally the same localities. The ivory supplied by the tusks of the former is one of the most valuable native products of this quarter of the globe. The rhinoceros is valued chiefly for its hide, which is made into shields and harness.
The *hippopotamus* is found in the upper part of the Nile valley, and in all the lakes and rivers to the southward of the Great Desert—includiing the Senegal, the Gambia, the Congo, and the Gariep. This animal is peculiar to Africa; its teeth consist of the finest ivory, for the sake of which it is hunted by the settlers of the Cape. All three of these animals are used as food by the native races of the South African interior.

28. The *wild boar* is found in some parts of Africa: the *zebra*, *dow*, and *quagga* (all peculiar to this continent) abound in its central and southern regions, particularly in the arid plains in the neighbourhood of the Orange river. Of the African quadrumaná, *monkeys*, *baboons*, and *lemurs*, abound in the forests throughout every part of the continent.

29. The *chimpanzee* of the western coasts (from the neighbourhood of Sierra Leone to the 10th parallel of S. latitude) makes nearer approach to the human form than the orang-oung of south-eastern Asia, but is surpassed in this respect by the *gorilla*, one of the largest of the ape tribe, which inhabits the forests in the neighbourhood of the Gaboon river (0° 30' N. lat.)

30. *Bats* are numerous in Africa, and most of the species inhabiting this continent are peculiar to it. The rodentia are also for the most part of peculiar species; among them are *hares*, *rabbits*, *jerboas*, *squirrels*, *rats*, and *mice*.

31. Among birds, the *ostrich* is confined to Africa, but ranges from its southern extremity to the northern borders of the Great Desert. Its feathers form a highly-valued article of traffic, and the bird is domesticated in many parts of Africa for the sake of procuring these free from injury. The *vulture* (of which two species occur—one in Northern Africa, and the other in the neighbourhood of the Cape) serves here, as elsewhere, to preserve the air from impurity, by feeding on the carcasses of animals, and divides with the hyena the office of scavenger. The *owl*, *falcon*, and *eagle*, are also enumerated amongst the African birds of prey. Of gallinaceous birds Africa possesses only the *Guinea fowl*; but the domestic poultry are numerously reared, though not indigenous. The woods of tropical Africa abound in numberless varieties of *parrots* and *parroquets*, besides many other birds of bright and gaudy plumage—as the beautiful *sun-birds* (which inhabit the western coasts, and are scarcely larger than the humming birds of America), together with the golden-coloured *orioles*, *crested hoopoes*, *bee-eaters*, and others. The *honey-suckers*, which abound in
the neighbourhood of the Cape of Good Hope, feed entirely upon the nectar or saccharine juice of the proteas and similar plants. The sun-birds also occur in Southern Africa, and rival those of India and the Gambia in the brilliancy of their colours.

32. Lizards, serpents, and reptiles of every description, abound in various parts of the African continent, though its general aridity, throughout extensive regions, is less favourable to the development of reptile life than in the case of correspondent latitudes elsewhere. The crocodile inhabits all the large rivers of tropical Africa, and is abundant in the lower portion of the Nile. The huge python, sometimes twenty-two feet in length (though inferior in size to the boa of the New World), is found in the swamps and morasses of the western coast, and some species of the cobra (or hooded snake) occur—chiefly in Southern Africa and on the shores of Guinea. Insects abound, both in species and as individuals; among them is the locust, which at intervals ravages all the northern parts of the continent. But the termites, or white ants, of Western Africa are the most celebrated members of the insect family, and effect the most extraordinary destruction of furniture, books, clothes, food, and everything that comes in their way. They build for themselves pyramidal or conical nests, firmly cemented together, and divided into several apartments—so large that at first sight they appear in the distance like the villages of the natives. Both the bee and the wasp are numerous distributed, but the bee has not been domesticated by any of the native people of this continent; it is, however, reared by the Arabs in Northern Africa.

33. Zoology of America.—The New World exhibits, through its vast prolongation in the direction of latitude, a development of animal life which is almost infinitely varied, and which differs in many essential regards from that belonging to either of the continents of the eastern hemisphere. Each of the nine orders of mammalia is represented within its limits, but many of the most attractive and valuable members of the animal life of Asia and Africa are nevertheless wanting. America has neither the elephant nor the camel; and neither the horse, the ox, the sheep, nor the hog, are indigenous to it.

34. The carnivora of the New World are inferior in size, strength, and ferocity, to those of Asia and Africa. In place of the lion, America has only the puma—a smaller and less powerful creature. The tiger of Southern Asia is represented by the jaguar, a somewhat
smaller animal, but the most powerful of the American carnivora. In North America, however, the numerous bears are distinguished by their size and power, particularly the grizzly bear of the countries which border upon the Rocky Mountains. The great white bear of the polar regions is common to the high latitudes of either hemisphere. North America, which is more strictly continental in extent than the southern half of the New World, possesses, indeed, other types of animal life which rival those of the eastern hemisphere. Among these are the majestic bison, or American buffalo (vast herds of which inhabit the immense prairies to the east of the Rocky Mountains),—together with the elk or moose-deer, occupying a place similar to the rein-deer of Northern Europe and Asia. Several varieties of the deer-kind occur in the northern half of the continent, together with the musk-ox, the big-horned sheep, and the Rocky Mountain goat, which are peculiar to this region.

35. The tapir and the peccary (an animal of the hog-kind) range all over the plains of South America, and the former is also found on the coast of Central America. The puma (or cougar) occurs on the Mexican Isthmus, and even as far northward as the 45th parallel, though found most numerously in the southern half of the continent, where its range extends to within a few degrees of the Strait of Magellan. The jaguar is found in the coast regions of the Mexican Isthmus, as well as the forests of Brazil and the adjoining regions of South America. The lynx and the wolf belong to the colder tracts of North America.

36. The opossums are numerous in South America, and one species is met with in the United States (Virginia); this family (marsupialia) is altogether absent from the eastern continent, but is fully developed in the Australian division of the globe. The beaver abounds in the colder latitudes of North America, together with a vast number of other fur-bearing animals; as raccoons, martens, squirrels, sea-otters, minks, musk-rats, ermines, foxes, wolverines, and hares.

37. The llama tribe (comprehending, besides the llama, the alpaca, vicuna, and others), is peculiar to South America. Its members are found throughout the prolonged cordilleras of the western side of that continent, from Chili to New Granada, dwelling always at considerable heights above the level of the sea. The llama belongs to the same order (ruminantia) as the camel of the Old World, and supplies some of the uses of that animal as a beast of burden. Prior to the Spanish conquest, the llama was, indeed, the only beast of
burden which the natives of South America possessed. The tapir of the same continent (an animal about the size of a small cow, and readily distinguished by the downward bend of its snout) belongs to the order of pachyderms. Two species of tapir, both of them peculiar to that region, inhabit South America: a third species is native to the island of Sumatra, and the adjacent Malay peninsula, in south-eastern Asia.

38. The paca and cutia (or agouti) both of a family which is peculiar to South America, take the place of the hare and rabbit of the Old World, and belong, like those animals, to the order of rodents. Both are used as food. The capybara and the common guinea-pig belong to the same order. The chinchilla, another of the South American rodents, valued for its delicate fur, is confined to the southern portions of the Andes.

39. The sloth, ant-eater, and armadillo (all belonging to the order of edentata), are natives of South America.

40. Monkeys are exceedingly numerous all over that continent, especially in the forests of Brazil. These, however, are different in species from the monkeys of the eastern hemisphere; they are of smaller size, and (with the exception of one nearly tail-less species, found within the forests of the Upper Amazons, within a very limited area) all possess tails, mostly prehensile. None of the apes of the New World make the same approach to the human form which is found either in the chimpanzee and gorilla of Western Africa, or the ourang of south-eastern Asia. Towards the close of the day the howling monkeys of Brazil make the woods resound with the most frightful cries; but they are neither of large size nor of formidable powers. The family of lemurs, so abundant in the eastern half of the globe, has not a single representative in the New World. The marmosets, a family confined to America, are numerous within the regions of the lower Amazons.

41. Bats are very numerous in South America,—more so than in any other part of the world: among them is the large vampire-bat, to which popular rumour has assigned the most bloodthirsty propensities, though it is in reality perfectly harmless, feeding chiefly upon fruits, with a few insects. All the American bats differ in species from those of the eastern continent.

42. The ornithology of tropical America exceeds in splendour that of any other region of the globe. Among the principal birds of prey
are several species of *eagle*—including the large white-headed eagle of the United States, with *vultures, hawks, kites,* and *owls.* South America, however, possesses the largest of the vulture-tribe—the gigantic *condor* of the Andes, which is confined to the higher peaks of those mountains, bordering on the limits of the snowy region. This is one of the most powerful and rapacious of birds, and commits numerous ravages amongst the cattle, deer, and other animals. The American ostrich, or *emu,* which dwells in the pampas of that region, is also distinguished by its size. The *turkey* is American, and is the only one of the domestic poultry that has been derived from the New World. The *toucans,* distinguished by their enormous bills, are peculiar to America.

43. The *humming-birds* are peculiar to the western continent, and in the tropical regions of America various birds of the most glittering plumage, together with numberless fire-flies, lend an almost magical charm to the aspect of nature. The range of the humming-birds extends over the whole continent to the southward of the 42d parallel (north lat.) and stretches upon the western side of North America as high as the parallel of 60°—an evidence of the superior warmth which distinguishes that side of the American continent.

44. Both reptiles and insects are abundant in the New World, which, owing to its excessive moisture and dense vegetation, is peculiarly suited to the development of these departments of the natural kingdom. Venemous serpents are more numerous in tropical America than in any other part of the globe. The *rattle-snake* occurs in both divisions of the continent, within the parallels of 44° to the northward, and of 30° to the south, of the equator; the huge *boa-constrictor,* the largest of the serpent tribe, and the terror even of the natives, dwells in the marshes and swamps of South America. Huge *caymans, iguanas,* and other lizards, with numberless *alligators* and *water-snakes,* abound in the rivers and temporary lagoons of the same region.

45. Zoology of Australia.—Australia possesses a zoology which is more distinctive than that of any other part of the world. Its native insects, reptiles, birds, and land animals, are all strikingly

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1 The *turkey* had been domesticated by the Mexicans, from whom the Spaniards introduced it into Europe. It had already become tolerably common in England before the close of the 16th century, and in Spain and the south of Europe much earlier in date.

The *potato,* *maize,* the *cinchona,* *tobacco,* and the *turkey,* have been pronounced the five great gifts of the New World to the Old.
different from those of other regions. The difference is greatest (or, at any rate, most obvious to ordinary observation) in the case of its land animals. Two-thirds of the Australian mammalia belong to the marsupial order, and the kangaroo, the largest member of that family, surpasses in size any other of its indigenous quadrupeds. The quadrupana, pachyderms, and ruminants are altogether unrepresented, nor are there any of the larger carnivora— the native dog (already verging on extinction) being the chief amongst them. The changes in zoological distribution which have been consequent on colonial enterprise in this region have been already adverted to. In the present day, large numbers of the Australian population are employed in rearing the domestic cattle of Europe.

46. Australia forms in all regards a distinct zoological province, and its insulated position has tended, in greater measure than is the case with any other part of the world, to confine the distinguishing features of its fauna within its own proper limits. The kangaroo family includes numerous distinct species, from the full-sized kangaroo down to the kangaroo-rat. But not a single one of the tribe is found beyond the limits of Australia and the neighbouring island of Tasmania. The opossums, which belong to the same order, are only found elsewhere in the New World. The most remarkable, however, amongst the members of the Australian animal world is that popularly known as the duck-bill (platypus, or ornithorynchus), which constitutes a puzzle to the naturalist. This is a semi-aquatic creature, about twelve or thirteen inches in length, with the body of an otter, a bill like that of the duck, and which lays eggs. As one of the tribe of mammalia (to which, by its habits, it belongs), the platypus must be classed under the head of the edentata: while, on the other hand, as being oviparous, it may be regarded as belonging to a totally distinct division of the animal world. The platypus frequents the margins of creeks and pools, but remains mostly in the water, and is only approached with difficulty, on account of its extreme shyness. It has a coating of soft fur, variously shaded from black to silver-grey.

47. Australia is distinguished by an extreme paucity of animal life (in so far as land-animals are concerned), in even a higher degree than by the limited number of its native species. This is readily explained by the generally arid character of its interior, the scantiness of the native vegetation, and the consequent difficulty of finding food. The traveller may frequently pass over many hundred miles
of country without meeting with a single quadruped, and almost
without finding the traces of a single land-animal. Its characteristics
in the latter regard are undergoing, however, a rapid change: the
*horse* and the *ox*, introduced by the European settlers, have in some
cases reverted to a state of nature, and a herd of wild cattle is now
not unfrequently met with, beyond the ordinary limits of the settlers' range.

48. The ornithology of Australia is richer and more varied than
other branches of its animal life. Its chief distinction consists in
the vast proportion of *suctorial* birds—that is, such birds as derive
their principal support from sucking the nectar of flowers. This
peculiar organisation, restricted, in Africa, India, and America, to
the smallest birds in creation, is here developed very generally, and
belongs to species that are as large as an English thrush. The *melli-
phagidæ*, or honey-suckers, take the place of the humming-birds of
the New World: like all the family to which they belong, they have
the tongue terminating in a brush-like bundle of very slender fila-
ments, with which they suck the nectar of flowers.

49. Among the native Australian birds are a vast number of the
parrot tribe, comprehending *paraquets*, *cockatoos*, and others, many
of them distinguished by the most beautiful plumage. Of birds of
prey, *eagles*, *falcons*, and *hawks* are numerous, as well as several *owls*.
The largest among the feathered tribes of Australia is the *emu*, or*cassowary*—a bird of the ostrich kind, though of rather inferior size
to the African ostrich. It is found chiefly in the southern portions
of the continent, but is yearly becoming scarcer under the advance of
the settlers.¹

50. The scattered islands of the Pacific, which, under the name of
Polynesia, constitute, in modern geography, one of the divisions of
the globe, can hardly be regarded as a distinct zoological region, so
obviously has their animal life been derived from other lands. When
first visited by European navigators, little more than a century since,
the largest quadruped found in the Polynesian groups was the hog,
which had probably accompanied the tribes of mankind by whom
they were peopled. The only other land animals were the dog,
mouse, and lizard, with a few rats. There were but few reptiles,

¹ The *emu* and *cassowary*, though in common language referred to as identical, are
specifically distinct. Of the *cassowary*, properly so called, three distinct species are
now known—one of them an inhabitant of the Australian mainland, in the neighbour-
hood of Cape York, a second native to New Guinea, and a third inhabiting the island of
New Britain.
or insects; fleas, scorpions, cock-roaches, and other vermin have since been introduced.

51. The native fauna of New Zealand is hardly less scanty than that of the smaller groups of the Pacific. The largest animal found there by the first European settlers was the pig, which is probably not indigenous, though it has reverted to a state of nature. Dogs are the only beasts of prey: a few rats and mice complete the list of its mammalia. There are no marsupials, though New Zealand is nearer by many thousand miles to Australia than to any of the other continents. The feathered tribes are equally few in number, but they include at least one species—now fast approaching extinction—the apteryx (wingless bird), which has no representative elsewhere. The moa, a bird of the ostrich kind, appears to have become extinct within the period of the present generation.

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Examination Questions.

1. What great division of the animal kingdom is recognised by naturalists? Say in what the distinction consists.

2. In what does the distinguishing attribute of the mammalia consist? Name the various orders into which they are divided, and give an instance of some animal coming under the head of each.

3. Give some particulars regarding the geographical range of animals—naming some that are characteristically found within warm and cold latitudes respectively, or only within the higher elevations of a mountain region.

4. What kind of differences are observed on comparing the animal life of the Old and New Worlds respectively?

5. Give some instances of changes effected by the agency of man, in respect of the animal life of various regions.

6. Name some of the carnivora found only within the Old World: also some of the pachyderms and ruminants.

7. To what portions of the globe are marsupials confined, and where are they most typically represented?

8. Give some particulars respecting European zoology.

9. Give some particulars respecting the zoology of Asia, naming particularly some of its carnivora.

10. Give some particulars respecting the zoology of Africa.

11. Give some particulars respecting the zoology of America.

12. Give some particulars respecting the zoology of Australia.
XV.

GEOGRAPHICAL DISTRIBUTION OF MAN.

1. Population of the Earth.—It is estimated that the Earth is inhabited, at the present time, by 1,500 millions of human beings, who are distributed over its surface in the manner shown in the following table:

<table>
<thead>
<tr>
<th>Continent</th>
<th>Area in British square miles</th>
<th>Population</th>
<th>Population to square mile</th>
</tr>
</thead>
<tbody>
<tr>
<td>Europe</td>
<td>3,700,000</td>
<td>334,000,000</td>
<td>90</td>
</tr>
<tr>
<td>Asia</td>
<td>17,500,000</td>
<td>826,000,000</td>
<td>47</td>
</tr>
<tr>
<td>Africa</td>
<td>12,000,000</td>
<td>200,000,000</td>
<td>16</td>
</tr>
<tr>
<td>North America (including West Indies)</td>
<td>8,600,000</td>
<td>70,000,000</td>
<td>8</td>
</tr>
<tr>
<td>South America</td>
<td>7,000,000</td>
<td>30,000,000</td>
<td>4</td>
</tr>
<tr>
<td>Oceania (including Malaysia, Australasia, and Polynesia)</td>
<td>4,000,000</td>
<td>40,000,000</td>
<td>10</td>
</tr>
</tbody>
</table>

2. Europe is therefore, relatively to its size, by much the most populous division of the globe, though Asia contains the highest number of inhabitants—amounting, indeed, to little less than two-thirds of the entire human race. The New World is very much less populated by man than the older-known portions of the globe, though its capabilities for the support of man fully equal those of any of the continents of the eastern hemisphere. Australia, and the scattered islands of the Pacific Ocean, are the least populous portions of the earth, the total present number of their inhabitants amounting to a mere fraction of the entire number.  

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1 The figures given in the above table represent no more than an approximate estimate. It is only in the case of Europe that we possess the means of making such calculations with any approach to accuracy. The amount of the population of China alone has been stated with wide variations—the estimates ranging between two hundred millions and more than double that number. We adopt above the higher number, which appears to be confirmed by the general testimony of observers. The number of inhabitants within the African continent (and especially within those portions of it populated by the negro race) is scarcely more than a guess: the figures given above are probably rather below than in excess of the truth.
3. The numerical distribution of mankind undergoes great change in the present day, when emigration from over-populated lands to distant parts of the globe is conducted on so extensive a scale. But this affects the distribution of race in much higher measure than it does the merely numerical distribution of man. The fast-increasing numbers of the settlers in the fertile plains and river-valleys of the New World, descendants of European colonists, perhaps hardly more than replaces, numerically, the native races who occupied the same regions prior to the first visit of the white man to their shores. It is the tendency, everywhere, of the native races to decay before the white settler. Wars, famine, epidemic diseases, and various social causes, again, tend to keep down the total number of the human family—at any rate, to check the more rapid numerical growth which it would otherwise exhibit.

4. Races.—The generally-recognised ethnological division of mankind, with reference to race, is into three leading families—the Caucasian, Mongolian, and Negro. Two other families—the Malay and the American—are commonly added to these, making five in the total. The first-named division is that suggested by the illustrious French naturalist, Cuvier. The fivefold division is due to the German philosopher, Blumenbach. In the scheme of the former, the Malay and American are regarded as sub-varieties—the one of the Caucasian, and the other of the Mongolian family. Other writers, again, enumerate a much greater number of varieties of mankind, each possessing characters sufficiently distinct to entitle it to be regarded as a separate family.

[In using the word race, as applied to different families of man, the division must be understood as implying "variety" only—not species. There is no specific difference in the various members of the human family—no difference, that is, which implies anything in contradiction to the assumption that all mankind have had a common origin, springing from a single pair. The human family differs in this regard from all the lower members of the animal kingdom. The order "bimana" (i.e., two-handed), to which, in scientific classification, man is referred, comprises only a single genus, and a single species.

The characteristic points of difference between the great families of mankind above referred to are—the colour of the skin, eyes, and hair (with the nature of the latter, whether curled, lank, woolly, or frizzled); and the shape of the skull. All other physical differences, as regards stature, form of limbs, and general outline of body, seem capable of ready explanation, by reference to opposite conditions of climate, food, and habits of social life. But between the Caucasian and the Negro, or the latter and the Mongol, there is a broad and strongly-marked difference, and one that extends over the whole historic period.]
5. Caucasian Race.—The distinguishing attributes of the Caucasian race, physically considered, are—the oval form of the skull, with the generally symmetrical shape of the entire head and frame of body. The face is of oval form, the features moderately prominent, the forehead arched, the cheek-bones only slightly projecting, the mouth small, the chin full and round; with the skin generally of light colour (varying, however, from white to a deep brown, or swarthy, hue), the eyes and hair of various hue, and the latter often curling. The facial angle\(^1\) is greater in the case of the Caucasian than in either of the other varieties of mankind.

6. The epithet Caucasian, applied to this branch of the human family, is derived from the high mountain-range which stretches between the Black and Caspian Seas, and is justified by the fact that the finest specimens of man—physically considered—have in all ages been found in proximity to that region. The perfect forms, and external beauty, of the Circassian and Georgian people—male and female alike—are well known. The finest types of the white race (mere physical beauty alone being considered) are to be found within the elevated region of the Caucasian isthmus; and it has even been sought to show that the human form degenerates in proportion as its distance thence, in whatsoever direction, is increased. To the westward of the Caucasus (whatever may be the case in other directions), the grace which attends on moral and intellectual dignity is, however, added to that of merely personal beauty.

7. Considered in reference to colour, the Caucasian is the white variety of the human family; but the latter epithet must be considered as applicable only in a general sense, for numerous shades of colour intervene between the swarthy complexions of the sub-tropical regions that border on the Mediterranean, and the fair skins of the people of northern and north-western Europe. These differences are doubtless in some measure dependent on climate. Yet there must be a well-grounded difference due to other causes, since families of whites dwell during several successive generations within the tropics without acquiring the hue of the negro, or settle within the western continent without gaining any external resemblance to the copper-coloured native of the New World.

\(^1\) The facial angle is formed by the meeting of two lines drawn on the profile of the skull—one of them a line touching the projecting part of the forehead and the gum of the upper jaw, the other connecting the base of the nose and the opening of the ear. The angle formed by the meeting of these lines sometimes amounts in a Caucasian variety of man to 80 degrees and upwards; in the other varieties it seldom exceeds 70 degrees; and in the instance of some degraded races is considerably less.
8. The geographical distribution of the Caucasian family in the present day is nearly co-extensive with the land-area of the globe; but this family of nations is most numerously developed within the temperate latitudes of the northern hemisphere. Western Asia, the European continent (with the exception of a portion in the extreme north), and the northern belt of Africa, are the proper home of the Caucasian tribes. Thence they have colonised nearly every part of the New World, as well as Southern Africa and the more distant regions of Australia and New Zealand, at the opposite side of the globe. Nine-tenths of the population of Europe belong to the Caucasian family of man, the small minority who constitute the exception consisting of the Turks, the Magyars, the Finns, the Laplanders, and the Samoiedes. In Asia, the Caucasian nations form but a minority of its vast population; they include, however, the natives of the Arabian or Semitic stock, the Persians, the Afghans, and perhaps also (such, at least, is the generally-received theory) the Hindus—that is, all the people dwelling to the south of the Himalaya, and to the west of the Bay of Bengal. In Africa, the proportion of Caucasians to its population is probably small, though they are spread over the whole of Northern Africa, from the Mediterranean to the southern border of the Desert, and the farthest limit of Abyssinia.

9. In America, the Caucasian family—settling in that part of the world as colonists only within the last three centuries and a half—is fast supplanting the indigenous races, and comprehends two-thirds of the total number of its inhabitants in the present day. Within the temperate latitudes of North America, that is, within the valleys of the Mississippi and St. Lawrence, with the Atlantic sea-board from the Gulf of St. Lawrence southward, the white race is most numerous. Five-sixths of the present population of North America belong, either in whole or in part, to the Caucasian stock.

10. In the case of Australia, the diminution in the numbers of the native race has been even more rapid than in the case of the Western continent. The white race, whose date of settlement on the Australian shores is as yet hardly more than three-quarters of a century, now vastly outnumbers the indigenous tribes. In Tasmania, the latter have indeed become extinct. Even in New Zealand, which was peopled by an athletic tribe of savages when Captain Cook visited it less than a century since, the colonial population, planted on its shores within the last forty years, now greatly outnumbers the
native tribes, which moreover undergo gradual diminution in numerical amount.

11. The Mongolian race.—The Mongolian variety of man is distinguished by a greater approach to squareness in the shape of the skull (viewed from above), with greater prominence in the cheek-bones—so that lines prolonged from the sides of the face upwards meet in a point, giving the entire framework of the head a pyramidal shape. The forehead is comparatively low and slanting; the face and nose broad and flat; the eyes deeply sunk, with the inner corner slanting towards the nose; the complexion of an olive or yellowish-brown colour, the hair lank and black, the beard scanty, the stature below that of Europeans, and the frame generally broad, square, and robust, with high shoulders, and the neck thick and strong. These attributes are much less strongly marked in the case of some nations of Mongol parentage than in others, and in the instances of the Magyars, Turks, and Finns—long settled amongst the Caucasian family—have in great measure disappeared. In point of colour, the Mongolian is known as the yellow variety of mankind.

12. The name of Mongolian, applied to this branch of the human family, is derived from the nomad races who people the upland plains of Central Asia. It comprehends, besides the Mongols proper, the vast population of China (above a third of the entire human family), together with the Burmese, Siamese, and other inhabitants of the south-eastern peninsula of Asia, and the native tribes of the Siberian lowland. The Turks and the Magyars, in south-eastern and central Europe, the Finns, Samoiedes, and Laplanders, in the extreme north of the same continent, and the Esquimaux, in the correspondent latitudes of the New World, belong to the same stock. In all, probably three-fifths of the population of Asia, and more than a half of the population of the globe, are comprehended within this division of mankind.

13. The Negro race.—The Negro, or black variety of mankind, is distinguished in general by the elongated form of the skull, combined with a low facial angle. The eyes, as well as the skin, are black; the nose broad, flat, and thick; the cheek-bones prominent; the lips thick; the jaws (especially the lower one) narrow and projecting; the hair woolly; the palms of the hands and the soles of the feet flat; and the forms of the arms and lower extremities generally clumsy and ungraceful. These attributes, however, are very much modified in the case of some members of the Negro race, and they belong in very
various degree to the different Negro nations who inhabit the African continent. The black skin, woolly hair, thick lips, and elongated skull, are the most striking features of the Negro race.

14. Africa, to the south of the desert, is the proper home of the Negro race. Tribes of true Negro stock occupy by far the larger portion of that great continent, to the southward of the Senegal, the Niger, the basin of Lake Chad, and the highlands of Abyssinia. The Arabs, however, have penetrated Central Africa within the basins of the Niger and Lake Chad, and have been settled for upwards of five centuries upon the coasts of Eastern Africa.

15. The Hottentot and Kaffir families, who inhabit the extreme south of the African continent, must be classed as sub-varieties of the Negro stock. The epithet negroid is generally applied to these races. But between the Hottentot and Negro types there is a well-marked distinction, and not less so between the Hottentot and the Kaffir families. The colour of the Hottentot is a dark and yellowish brown; the hair short and frizzled, and distributed over the head in tufts; the stature short. The Kaffirs are well-made, and (comparatively to their neighbours of Hottentot race) of muscular frame—their limbs of rounded form, their skin of deep brown colour, their hair short, black, and curly, but less woolly than that of the Negro.

16. The Negro race, through the iniquities of the slave-trade, has been transplanted from Africa to the other side of the Atlantic, and now forms a considerable item in the population of the New World. In North America, the people of pure Negro blood amount, however, to hardly more than a twelfth part of the total population; in South America the proportion is perhaps rather more considerable.

17. The Malay race.—The Malay, or brown family of nations, is distinguished, besides the colour of the skin, by lank, coarse, and black hair; with flat faces, and obliquely-set eyes. Their stature is below the average height either of the Caucasian or the Negro, and the figure generally square and robust.

18. If the nations of the Malay family are to be referred to one of the three greater divisions, they must be regarded as a sub-variety either of the Mongol or the Negro stock. Proximity of geographical position, with other circumstances, would lead us to prefer the former. The Papuans, however, who inhabit New Guinea and the adjacent islands to the eastward, exhibit many of the characteristics of the Negro type, and the native race of Australia is of the Papuan or
Austral-negro family. There is, in truth, throughout the Australian and Polynesian division of the globe, a well-marked distinction between the brown and the black races. The former, who belong to the true Malay family, comprehend, with the Malays proper (that is, the bulk of the inhabitants of the Malay peninsula and the adjacent islands), the people of Madagascar; also the New Zealanders, and the inhabitants of most of the smaller Polynesian archipelagoes, from the Sandwich Islands on the north, to the Society, Navigators, and Friendly groups in the south. The Austral-negro or Papuan division, on the other hand, includes the native tribes of the Australian continent and the adjacent island of Tasmania (the latter now all but extinct), with the inhabitants of New Guinea, the Louisiade archipelago, New Britain, the Solomon Islands, the New Hebrides, New Caledonia, and the Fiji Islands.

19. The American race.—The American, or red variety of mankind, has its home in the two great continents which are together known as the New World. Its distinguishing attributes are—a reddish or copper-coloured skin, with long, coarse, black hair (which is never crisped like that of the negro, or curled, as that of the white often is), and scanty beard. The cheek-bones are prominent, but more arched and rounded than those of the Mongol, without being so angular, or projecting at the sides; the orbit generally deep, and the outer angle slightly elevated. In point of temperament, the Indian (as the native inhabitant of the American wilderness is termed) is cold and phlegmatic to an unusual degree, and he manifests an extraordinary insensibility to bodily pain. His bodily senses—of sight, hearing, and smell—are remarkably acute. These, as well as many other attributes of the Indian race, have probably resulted from the conditions of the hunter's life, pursued through many generations.

20. The above characteristics, however, are exhibited in widely-different measure in the case of the numerous native tribes and nations that are found through the whole wide extent of the American continent, though all of them (with the exception of the Esquimaux) are classed under the common term Indian. The native races of South America are generally further removed than those of North America from the higher type of the American family, and they become progressively more degraded towards its furthest extremity. Some of the Indian tribes who dwell in the Brazilian forest exhibit a degree of personal ugliness, and a degradation of condition in general, which contrasts strikingly with that of the higher classes of North
American Indians, and the native savages of Tierra del Fuego are among the most misshapen and degraded of the human race. In these and some other cases, the distortion of feature, and even that observable in the shape of the head, is produced by artificial means, applied in infancy.

21. The Indian family of nations makes perhaps nearer approach to the Mongol than to either of the other two great divisions of mankind, and must be regarded as a sub-variety of that family, if three great varieties only be allowed. The Eskimo, who inhabit the extreme northern shores of the New World, are uniformly regarded as of Mongol origin.

EXAMINATION QUESTIONS.

1. To what, in round numbers, does the estimated population of the globe amount?
2. Which of the continents has the largest absolute number of inhabitants? Which the next largest number? Which the least number?
3. In which continent is the proportionate population (i.e., the number of persons to a square mile) largest? In which smallest?
4. What conditions tend to check the numerical increase of mankind? In what parts of the world is the increase in numbers most rapid in the present day, and by what condition is it aided?
5. Into what three families are mankind divided? What two other families are added by some writers—making, in the whole, five divisions?
6. State some of the distinguishing attributes of the Caucasian race.
7. Whence is the epithet Caucasian derived?
8. Over what portions of the globe is the Caucasian family distributed at the present time?
9. Describe the distinguishing attributes of the Mongol variety of mankind.
10. Describe the distinguishing attributes of the Negro family.
11. What two families are classed as sub-varieties of the Negro stock? Where do they dwell?
12. Over what portions of the globe is the Negro race now distributed? Through what means?
13. Describe the distinguishing features of the Malay family of nations.
14. Describe the distinguishing features of the American family.
15. To what family do the Eskimo belong? In what parts of the globe are they found?
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