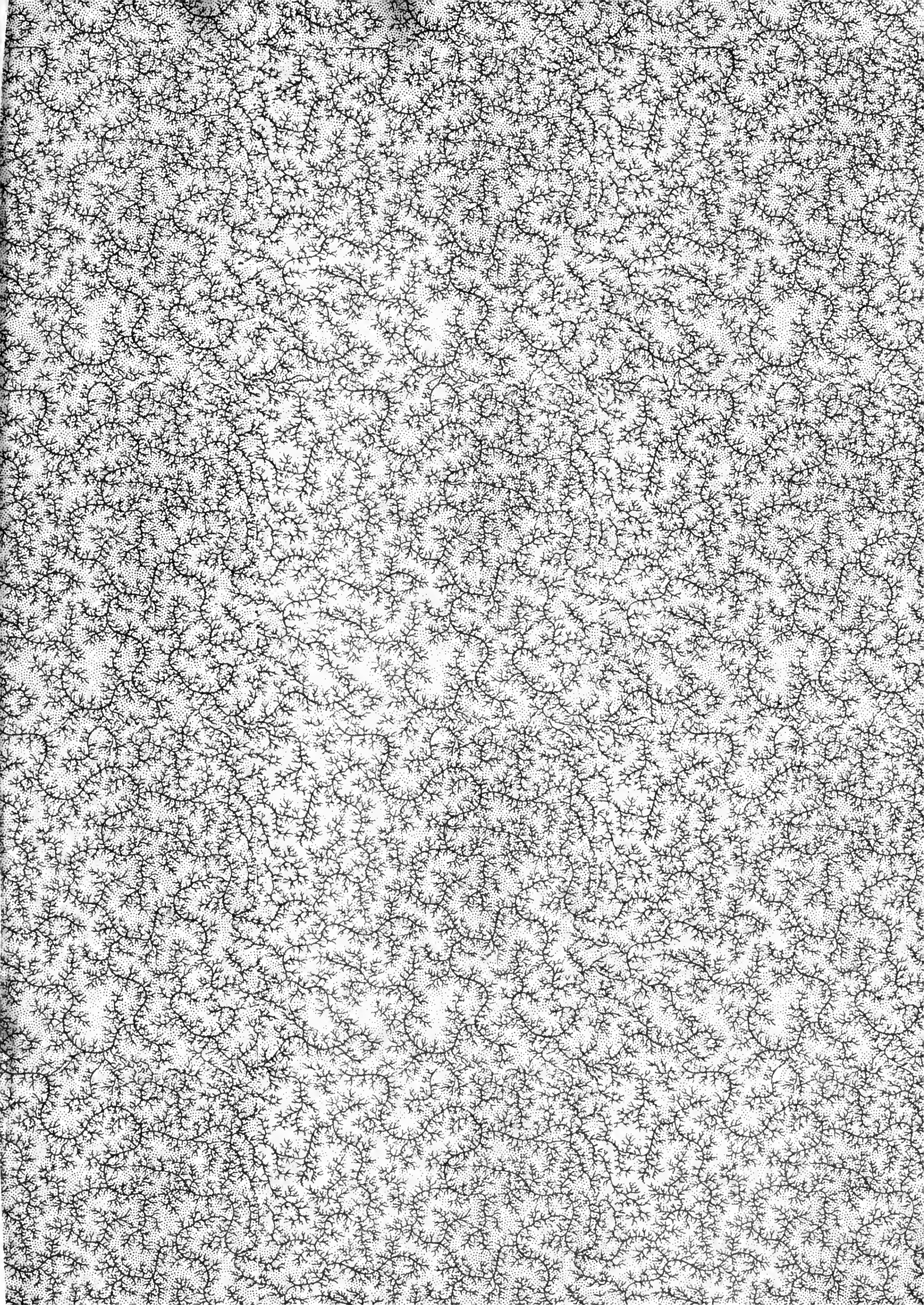
HOUSTON'S NEW PHYSICAL GEOGRAPHY



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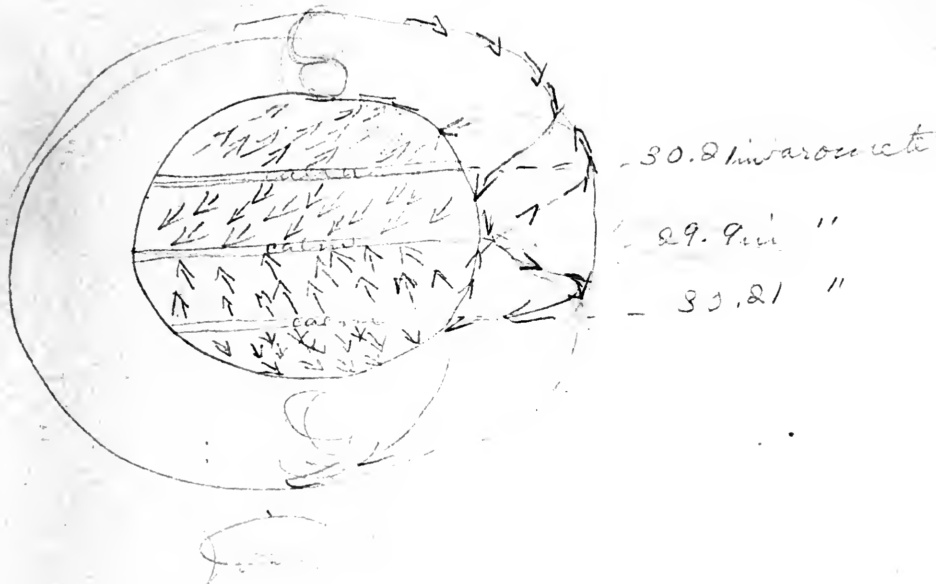
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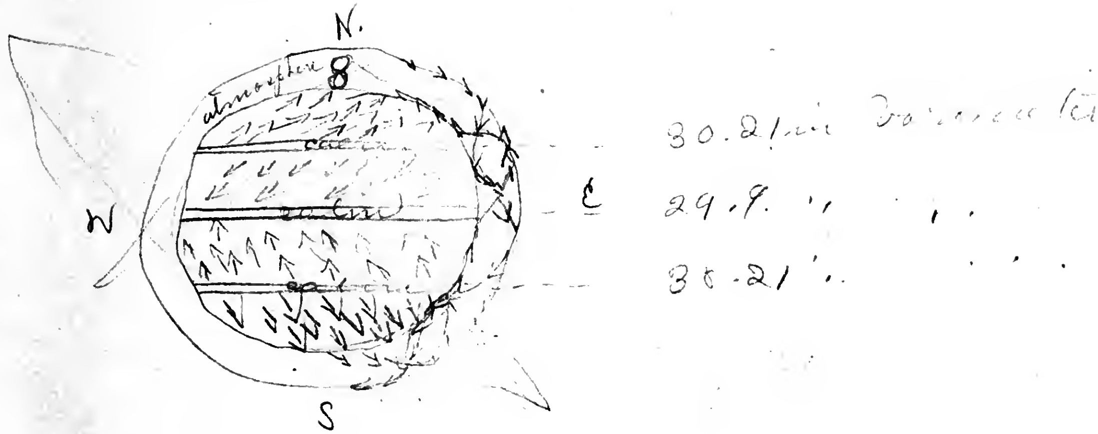
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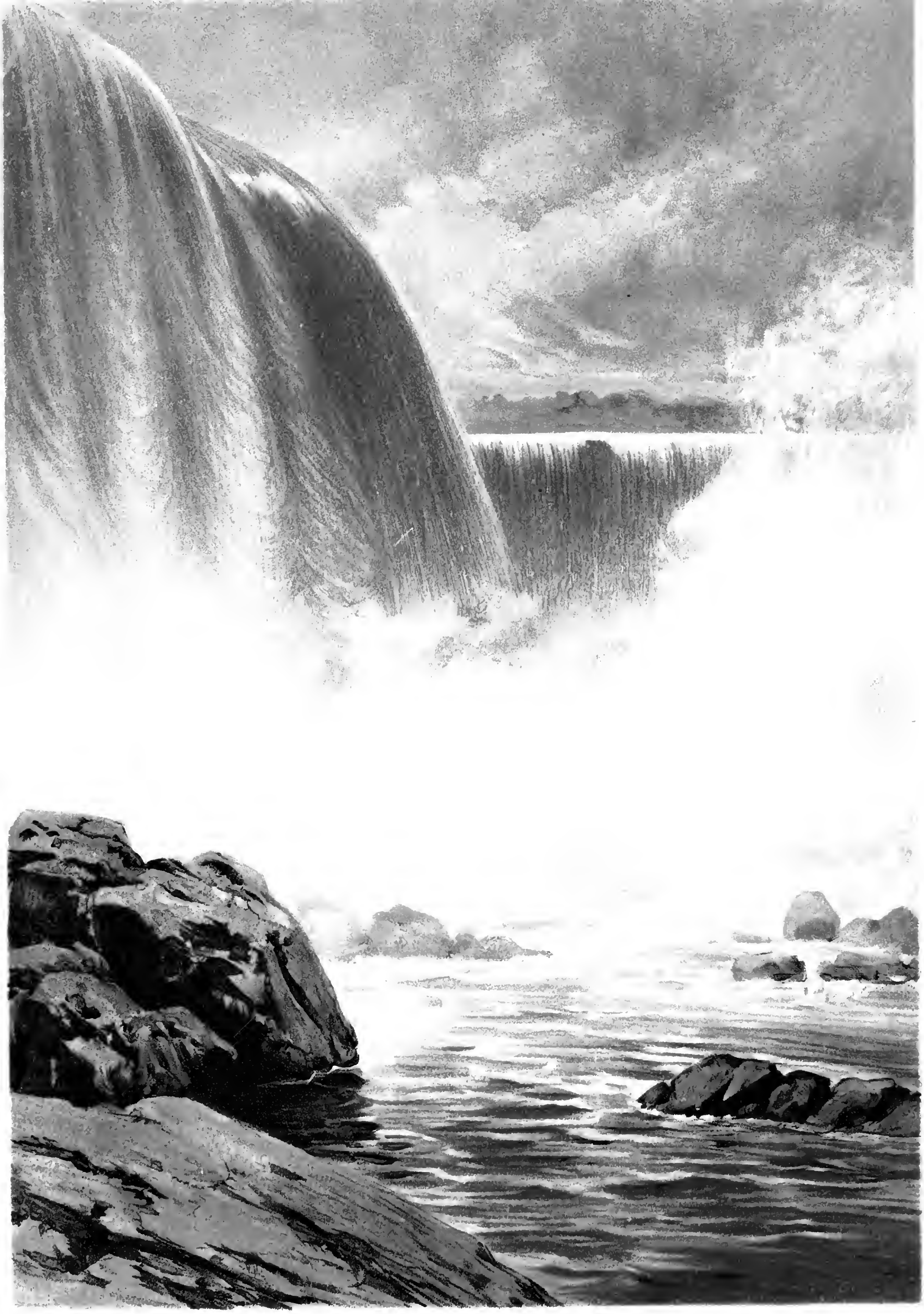

THE FALLS OF NIAGARA.

THE ELEMENTS

OF

PHYSICAL GEOGRAPHY,

FOR THE USE OF

SCHOOLS, ACADEMIES, AND COLLEGES.

BY

EDWIN J. HOUSTON, A.M.,

PROFESSOR OF PHYSICAL GEOGRAPHY AND NATURAL PHILOSOPHY IN THE CENTRAL HIGH SCHOOL OF PHILADELPHIA; PROFESSOR OF PHYSICS IN THE FRANKLIN INSTITUTE OF THE STATE OF PENNSYLVANIA.

REVISED EDITION.

PHILADELPHIA:
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No. 17 North Seventh Street.
1892.

A SERIES OF TEXT-BOOKS

ON

THE NATURAL SCIENCES.

By Prof. E. J. HOUSTON.

1. Easy Lessons in Natural Philosophy.
2. Intermediate Lessons in Natural Philosophy.
3. Elements of Natural Philosophy.
4. Elements of Physical Geography.

The Easy Lessons in Natural Philosophy is intended for children. It is arranged on the "question-and-answer" plan; but the answers, in almost every case, contain in themselves a distinct statement apart from the question, thus removing the objections of those who are opponents of the "question-and-answer" plan of teaching; which, if properly used, is shown by experience to be one of the best methods of reaching the mind of a young child.

The Intermediate Lessons in Natural Philosophy is designed for the use of pupils who have finished such books as Houston's "Easy Lessons in Natural Philosophy," Martindale's "First Lessons in Natural Philosophy," Swift's "First Lessons in Natural Philosophy," Hotze's "First Lessons in Physics," Parker's "Natural Philosophy," Part I., Peterson's "Familiar Science," and other similar books, but who are not sufficiently advanced to take up the larger text-books. Its publication was determined upon at the request of teachers in many parts of the country, who have felt the need of a book of this grade to meet the wants of their own classes. So far as we know, there is no other book in the market which fills the want here indicated.

The Elements of Natural Philosophy is intended for High Schools, Academies, Seminaries, Normal Schools, etc. It gives the elements of the science in a concise form and in logical sequence, so that the book forms a system of Natural Philosophy, and not a mere collection of disconnected facts. It is fully "up to the times" in every respect, and gives full descriptions of the most important discoveries recently made in Physical Science. The Electric Light, the Telephone, the Microphone, the Phonograph, etc. are all described and illustrated. Teachers will be well pleased with this book. It will give satisfaction wherever introduced.

Westcott & Thomson,
Electrotypers, Philada.

The George S. Ferguson Co.,
Printers, Philada.

PREFACE

TO THE ORIGINAL EDITION.

IN the preparation of this work, an endeavor has been made to supply a concise yet comprehensive text-book, suited to the wants of a majority of our schools.

The Author, in the course of his teaching, has experienced the need of a work in which unnecessary details should be suppressed, and certain subjects added, which, though usually omitted in works on Physical Geography, seem, in his judgment, to belong properly to the science. The variety of topics necessarily included under the head of Physical Geography renders it almost impossible to cover the entire ground of the ordinary text-books during the time which most schools are able to devote to the study, and the feeling of incompleted work thus impressed on the mind of both teacher and scholar is of the most discouraging nature.

To remove these difficulties, the Author, during the past few years, has arranged for his own students a course of study, which, with a few modifications, he has at last put into book form, thinking that it may prove beneficial to others.

The division of the text into large and small print has been made with a view of meeting the wants of different grades of schools, the large type containing only the more important statements, and the small type being especially designed for the use of the teacher and the advanced student. The maps have been carefully drawn by the Author according to the standard works and the latest authorities. Neither time nor expense has been spared to insure accuracy of detail and clearness of delineation.

Throughout the work no pains have been spared to insure strict accuracy of statement. Clearness and conciseness have been particularly aimed at; for which reason the names of authorities for statements which are now generally credited have been purposely omitted.

The Author has not hesitated to draw information from all the standard works on Geography, Physics, Geology, Astronomy, and other allied sciences; and in the compilation of the Pronouncing Vocabulary he acknowledges his indebtedness to Lippincott's Gazetteer of the World.

Acknowledgments are due to Mr. William M. Spackman, of Philadelphia, and Prof. Elihu Thomson, of the Central High School, for critical review of the manuscript. Also to Mr. M. Benjamin Snyder, of the Central High School, for revision of the proof-sheets of the chapter on Mathematical Geography.

E. J. H.

CENTRAL HIGH SCHOOL, Philadelphia, Pa.

PREFACE

TO THE REVISED EDITION.

THE marked progress which has been made in most of the departments of science embraced in the study of Physical Geography since the issue of the original edition of "The Elements of Physical Geography" has rendered the preparation of a revised edition a matter of necessity.

The study of Physical Geography, including as it does not only the crust of the earth and its heated interior, but also the distribution of its land, water, air, plants, and animals, includes, in its range, a great variety of topics, and necessitates for its proper elucidation many branches of science. Some knowledge of the elementary principles of these sciences is necessary to the proper study of Physical Geography. The number of such principles is great, and the temptation naturally exists to encumber even an elementary text-book with such an abundance of leading principles as to render it either incomprehensible, or too extended for actual use in the school-room.

The author has endeavored in the revised edition to avoid undue multiplicity either of elementary principles or unimportant details. His object has been to develop forcibly the close interdependence of the inanimate features of the earth's surface, the land, water, and air, with its animate features, its flora, and fauna, and to show the marked influence which all of these exert on the development of the human race, and, therefore, on history itself.

Recognizing, from his standpoint of a teacher, the inadvisability of crowding a book with new matter simply because it is new, the author has carefully avoided the introduction of new theories unless they have been generally accepted by the best authorities. Old theories are in all cases given the preference of new ones, unless the latter bear the stamp of general approval. At the same time the results of recent investigations have been freely given in all cases where they have been considered sufficiently authoritative.

In order to avoid confusing the mind of the student, controversial matters have been carefully avoided. When, however, opinion on any subject is fairly divided, a brief statement is made of the differing views.

The favorable reception accorded by the teaching profession to the earlier editions of the book, and the flattering increase in the number of schools using it, have satisfied the author of the inadvisability of changing, to any considerable extent, the order of sequence of topics discussed, or the general manner of explanation therein adopted.

In the preparation of the revised edition the author has freely consulted the latest standard authorities in the many sciences represented.

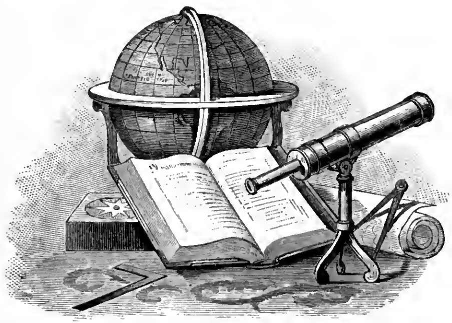
The maps have all been re-drawn according to the best authorities, and are printed and colored by processes that in point of clearness and beauty leave little room for improvement.

EDWIN J. HOUSTON.

CENTRAL HIGH SCHOOL,
PHILADELPHIA, Jan., 1891.

NOTE.

The first chapter of this book is intended mainly for reference, containing as it does, an abstract of the elementary principles of Mathematical Geography, with which most pupils beginning the study of Physical Geography are familiar. In many schools in which the book is used, it is customary to begin the formal study of the book with the Syllabus, page 21, which presents a comprehensive review of the chapter, and in practice and results this plan has proved satisfactory.



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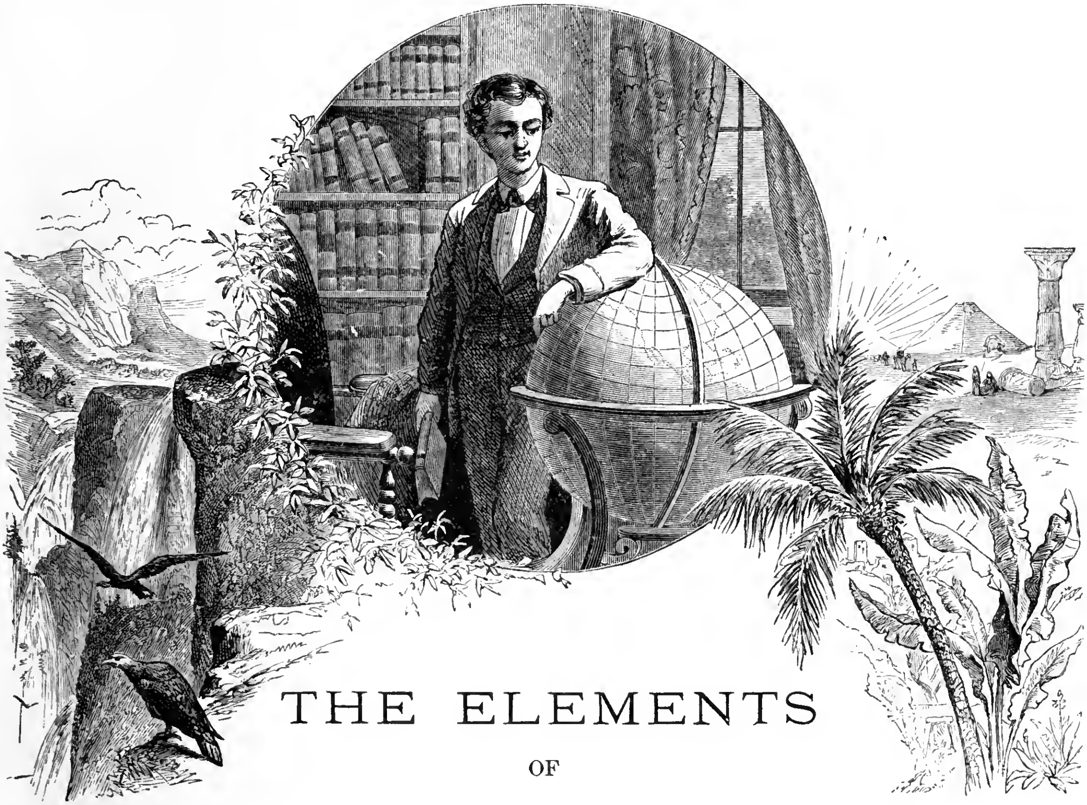


THE ELEMENTS

OF

PHYSICAL GEOGRAPHY.

INTRODUCTORY.

1. Geography is a description of the earth.

The earth may be considered in three different ways:

(1.) In its relations to the solar system;
(2.) In its relations to government and society;
(3.) In its relations to nature.

Hence arise three distinct branches of geography—Mathematical, Political, and Physical.

2. Mathematical Geography treats of the earth in its relations to the solar system.

Mathematical Geography forms the true basis for accurate geographical study, since by the view we thus obtain of the earth in its relations to the other members of the solar system, we are enabled to form clearer conceptions of the laws which govern terrestrial phenomena. Here we learn the location of the earth in space, its size, form, and movements, its division by imaginary lines, and the methods of representing portions of its surface on maps.

3. Political Geography treats of the earth in its relations to the governments and societies of men, of the manner of life of a people, and of their civilization and government.

4. Physical Geography treats of the earth in its relations to nature and to the natural laws by which it is governed. It treats especially of the systematic distribution of all animate and inanimate objects found on the earth's surface. It not only tells of their presence in a given locality, but it also endeavors to discover the causes and results of their existence.

Physical Geography, therefore, treats of the distribution of five classes of objects—*Land, Water, Air, Plants,* and *Animals.*

Geography deals with the inside as well as with the outside of the earth. It encroaches here on the province of geology. Both treat of the earth: geography mainly with the earth's present condition; geology with its condition both in the past and present, though mainly during the past.

Some authors make physical geography a branch of geology, and call it physiographic geology, but we prefer the word "physical," or as the etymology would make it, "natural" geography.

PART I.

THE EARTH AS A PLANET.

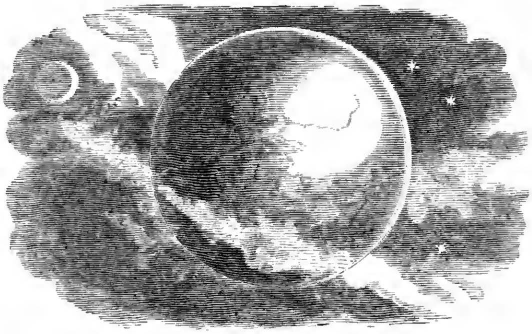


Fig. 1. The Earth in Space.

CHAPTER I.

Mathematical Geography.

5. The Earth moves through empty space around the sun. The old idea of the earth resting on, or being supported by something, is erroneous. The earth rests on nothing.

A book or other inanimate object placed on a support will remain at rest until something or somebody moves it, because it has no power of self-motion. This property is called *inertia*.

Inertia is not confined to bodies at rest. If the book be thrown up through the air, it ought to keep on moving upward for ever, because it has no more power to stop moving than to begin to move. We know, however, that in reality it stops very soon, and falls to the earth; because—

(1.) The earth draws or attracts it;

(2.) The falling body gives some of its motion to the air through which it moves.

Were the book thrown in any direction through the empty space in which the stars move, it would continue moving in that direction for ever, unless it came near enough to some other body which would attract it and cause it to change its motion.

Our earth moves through empty space around the sun, and, on account of its inertia, must *continue so moving for eternities.* There are ample reasons for believing that all the heavenly bodies continue their motion solely on account of their inertia. The mutual attraction or gravitation of neighboring bodies for each other produces, as will be hereafter explained, the curved paths in which they move.

Space is not absolutely empty, but is everywhere filled with a very tenuous substance called ether, which transmits to us the light and heat of the heavenly bodies. Wherever the telescope reveals the presence of stars we must believe the ether also extends.

6. The Stars.—The innumerable points of light that dot the skies are immense balls of matter which, like our earth, are moving through empty space. Most of them are heated so intensely that they give off heat and light in all directions. They are so far from the earth that they would not be visible but for their immense size. Beyond them are other balls, also self-luminous, but too far off to be visible except through a telescope. Beyond these, again, we have reason to believe that there are still others. *These balls of matter are called stars.* All the heavenly bodies, however, do not shine by their own light. A few—those nearest the earth—shine by reflecting the light of the sun. These are called planets, and move with the earth around the sun.

7. The Solar System comprises the sun, eight large bodies called *planets,* and, as far as now known, two hundred and eighty-one smaller bodies called *planetoids* or *asteroids,* besides numerous *comets* and *meteors.* Some of the planets have bodies called *moons* or *satellites* moving around them. These also belong to the solar system.

Fig. 2 represents the solar system. In the centre is the sun. The circles drawn around the sun show the *paths* or *orbits* of the planets. These orbits are represented as circular, but in reality they are slightly flattened or elliptical. The elongated elliptical orbits mark the paths

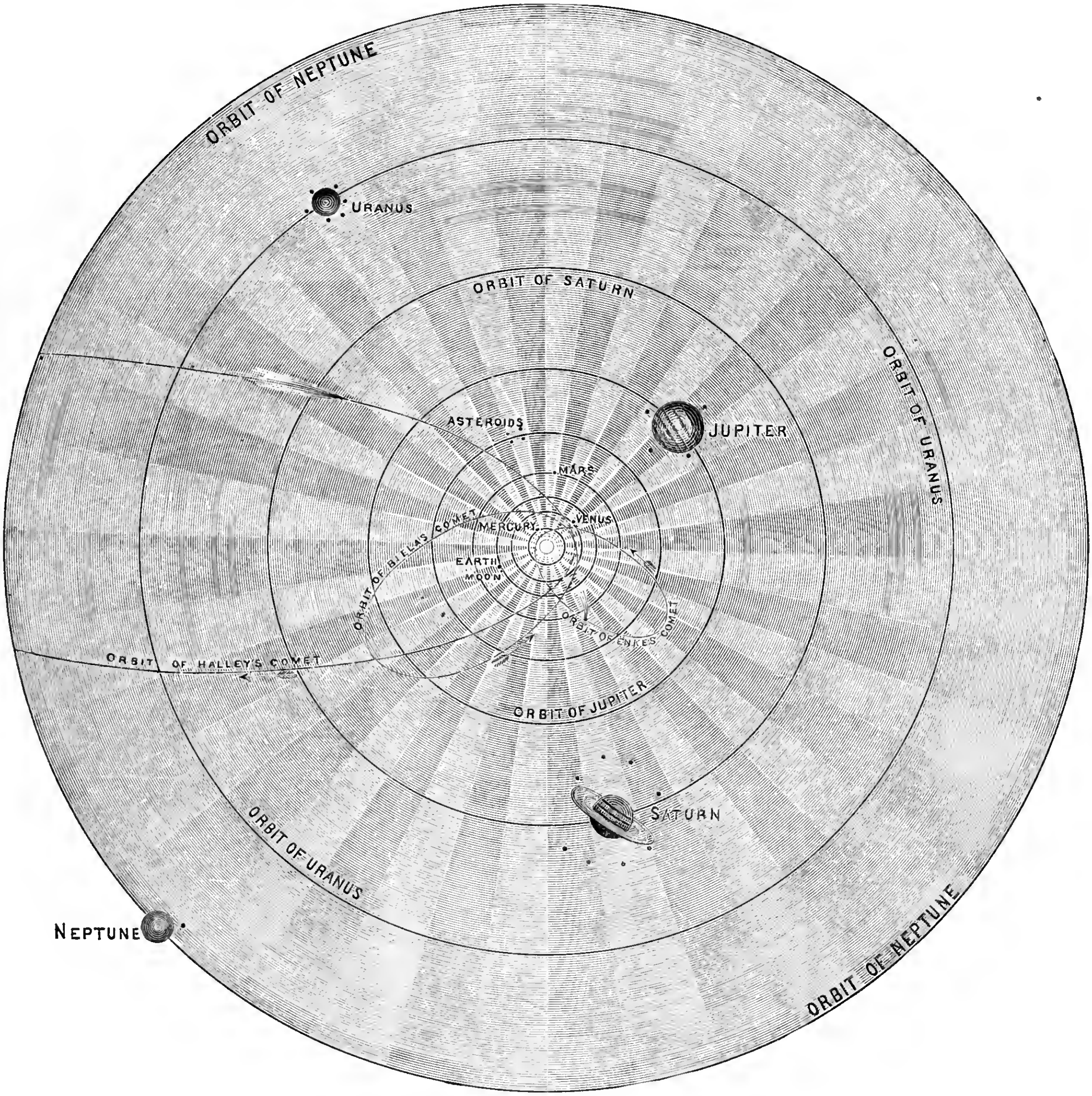


Fig. 2. The Solar System.

of the comets. The drawing shows both the relative distances of the planets and their sizes as compared with each other and with the sun, the relative size of the sun being that of the orbit of Neptune.

8. Names of the Planets.—The planets, named in their regular order from the sun, beginning with the nearest, are as follows—viz.: *Mercury, Venus, Earth, Mars, Jupiter, Saturn, Uranus,* and *Neptune.* The first four—*Mercury, Venus, Earth,* and *Mars*—are comparatively small; the second four—*Jupiter, Saturn, Uranus,* and *Neptune*—are very large, Jupiter being nearly fourteen hundred times larger than the earth. The initial letters of the last three planets, Saturn, Uranus, and Neptune, taken in their order from the sun: s, u, and n—spell the name of their common centre.

* Mercury has a mean or average distance of 36,000,000 of miles from the sun; Venus, 67,200,000; Earth, 92,900,000; and Mars, 141,500,000.

Jupiter is 483,000,000; Saturn, 886,000,000; Uranus, 1,781,900,000; Neptune, 2,791,600,000. The asteroids move around the sun in the space between the orbits of Mars and Jupiter.

* Calculated in round numbers for the mean solar distance of 92,897,000 miles.

It is difficult to obtain clear conceptions of distances that are represented by millions of miles. We may learn the numbers, but in general they convey no definite ideas. Should a man travel forty times around the earth at the equator, he would only have gone over about 1,000,000 miles. Now, Mercury, the nearest of the planets, is thirty-six times farther from the sun than the entire distance the man would have travelled, while Neptune is nearly three thousand times the distance he would have travelled.

9. The Satellites.—A satellite is a body that revolves around another body: the planets are satellites of the sun; the moon is a satellite of the earth. Mars has two moons. So far as is known, neither Mercury nor Venus has a satellite. All the planets whose orbits are beyond the orbit of the earth have moons: Jupiter has four, Uranus six, Saturn eight, and Neptune one. Besides its moons, Saturn has a number of curious ring-like accumulations of separate solid or liquid particles revolving around it. The earth's moon is about 240,000 miles from the earth. Its volume is about one-forty-ninth that of the earth's.

10. The Sun is the great central body of the solar system. Around it move the planets with their satellites, receiving their light and heat from it. The sun is a huge heated mass about 1,300,000 times the size of the earth. Its diameter is about 866,500 miles. It appears the largest self-luminous body in the heavens because it is comparatively near the earth. Many stars which appear as mere dots of light are much larger than the sun.

The sun is a body heated to luminosity, and gives out or emits light and heat like any other highly-heated body. If no causes exist to maintain its heat, it will eventually cool and fail to emit light. The sun's heat is partly kept up by a variety of causes, the principal of which is the heat developed by meteoric showers that fall on its surface. If a meteor fall toward the sun from interplanetary space, it will reach the surface with enormous velocity, and its motion will there be converted into heat. Since, however, the increase of the sun's mass so necessitated is not confirmed by astronomical observations, it is believed that the sun's heat is not being maintained in this way, and that the sun must eventually cool —an event, however, so remote in time that the life of the solar system may be regarded as practically infinite.

Size of the Sun.—Were the sun hollow and the earth placed at its centre, there would not only be sufficient room to enable the moon to revolve at its present actual distance around the earth, but it would still, in all parts of its orbit, be nearly 200,000 miles below the surface of the sun.

All the fixed stars are distant suns, and probably have worlds like our own moving around them.

From the enormous distances of the fixed stars, we are obliged, in estimating their distances, to use for our unit of measurement the velocity of light. Any other common unit would be too small. Light moves through space at the rate of about 186,000 miles a second, which is over 11,000,000 miles a minute. Notwithstanding this prodigious velocity, it would take over three thousand years for light to reach the earth from some of the stars that are visible to the naked eye. But beyond these stars the telescope reveals myriads of others, whose number is limited only by the power of the instrument. We may conclude that the universe is as boundless as space; that is, light can never reach its extreme limits.

11. Cause of the Earth's Revolution.—The earth's motion through space is caused solely by a *projectile force* imparted to it when it began its separate existence, probably when first thrown off from the nebulous sun. From its *inertia* it would move for an indefinite time in one direction, but by the *sun's attraction* it is constantly changing its direction by falling toward the sun; and thus is produced the curved shape of its orbit. Under the influence of the projectile force alone the earth would move

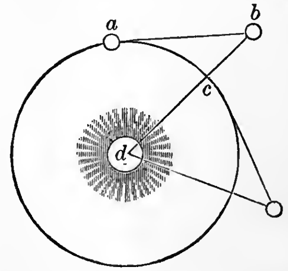


Fig. 3. Cause of the Curved Shape of the Earth's Orbit.

through space from *a* to *b* (Fig. 3); but during this time it has been continually changing its direction by an amount equivalent to a direct fall from *b* to *c* along the line *b d*; hence its real orbit, during this time, is along the curved line from *a* to *c*.

12. Position of the Solar System in Space.—The sun, with all the bodies which move around it, is in that portion of the heavens called the *Milky Way*. The sun is an insignificant star among the millions of other stars the telescope has revealed to us.

It was formerly believed that the sun was stationary, for it was not then known that the positions of the fixed stars were undergoing slight variations as regards the earth. It is now generally conceded that the sun, with all the planets, is moving through space with tremendous velocity, the direction at present being toward the constellation Hercules. The astronomer Maedler, however, believes that the grand centre around which the solar system is moving is Alcyone, the brightest star in the constellation of the Pleiades. The estimated velocity of the sun in its immense orbit is 1,382,000,000 miles per year. As the earth is carried along with the sun in its orbit, it is continually entering new realms of space.

13. The Earth.—The shape of the earth is that of a round ball or sphere slightly flattened at two opposite sides. Such a body is termed a *spheroid.* There are two kinds of spheroids—*oblate* and *prolate;* the former has the shape of an orange, the latter that of a lemon.

The straight line that runs through the centre of a sphere or spheroid and terminates at the circumference is called the *diameter*. If the sphere rotates—that is, moves around like a top—the

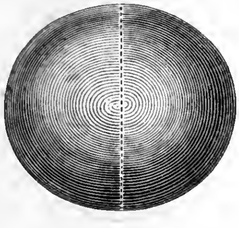


Fig. 4. Oblate Spheroid.

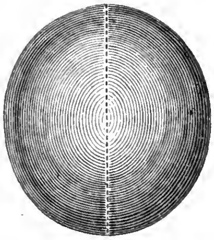


Fig. 5. Prolate Spheroid.

diameter on which it turns is called its *axis*. In the oblate spheroid the axis is the shorter diameter; in the prolate spheroid the axis is the longer diameter.

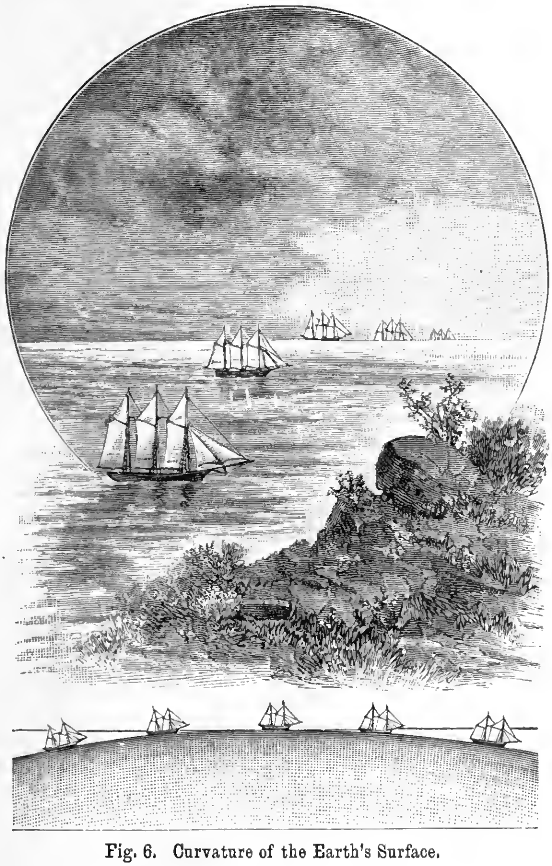


Fig. 6. Curvature of the Earth's Surface.

The shape of our earth is that of an *oblate spheroid.* The polar diameter is 26.47 miles shorter than the equatorial diameter.

14. Proofs of the Rotundity of the Earth.—The earth is so large a sphere that its surface everywhere appears flat. The following simple considerations will prove, however, that its form is nearly spherical:

(1.) **Appearance of Approaching Objects.**—If the earth were flat, as soon as an object appeared on the horizon we would see the upper and lower parts at the same time; but if it were curved, the top parts would first be seen. Now, when a ship is coming into port we see first the topmasts, then the sails, and finally the hull; hence the earth must be curved; and, since the appearance is the same no matter from what direction the ship is approaching, we infer that the earth is evenly curved, or spherical.

(2.) **Circular Shape of the Horizon.**—The horizon—or, as the word means, the boundary—is the line which limits our view when nothing intervenes. The fact that this is *always a circle* furnishes another proof that the earth is spherical.

The horizon would still be a circle if the earth were perfectly flat, for we would still see equally far in all directions; but it would not everywhere be so, since to an observer near the edges some other shape would appear. It is on account of the spherical form of the earth that our field of view on a plain is so soon limited by the apparent meeting of the earth and sky. As we can only see in straight lines, objects continue visible until they reach such a distance as to sink below the horizon, so that a straight line from the eye will pass above them, meeting the sky far beyond, on which, as a background, the objects on the horizon are projected.

(3.) **Shape of the Earth's Shadow.**—We can obtain correct ideas of the shape of a body by the shape of the shadow it casts. Now, the shadow which the earth casts on the moon during an eclipse of the moon is always circular, and as only spherical bodies cast circular shadows in all positions, we infer that the earth is spherical.

(4.) **Measurement.**—The shape of the earth has been accurately ascertained by calculations based on the measurement of an arc of a meridian. We therefore not only know that the earth is oblately spheroidal, but also the exact amount of its oblateness.

(5.) **The Shape of the Great Circle of Illumination,** or the line separating the portions of the earth's surface lighted by the sun's rays from those in the shadow, is another evidence of the rotundity of the earth.

15. The Dimensions of the Earth.—The equatorial diameter of the earth, or the distance through at the equator, is, approximately, 7926 miles; its polar diameter, or the length of its axis, is 7899 miles. The circumference is 24,899 miles. The entire surface is equal to nearly 197,000,000 square miles.

The specific gravity of the earth is about $5\frac{2}{3}$; that is, the average weight of all the materials that constitute it is five and two-third times heavier than an equal volume of water.

16. Imaginary Circles.—In order to locate places on the earth, as well as to represent portions of its surface on maps, we imagine the earth to be encircled by a number of curved lines called great and small circles.

A great circle is one which would be formed on the earth's surface by a plane passing through the earth's centre, hence dividing it into two equal parts. All great circles, therefore, divide the earth into hemispheres.

The formation of a great circle on a sphere by cutting it into two equal parts is shown in Fig. 7.

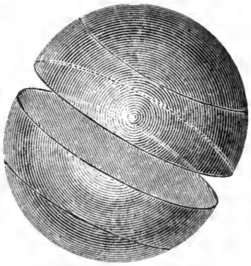


Fig. 7. Great Circle.

The shortest distance between any two places on the earth is along the arc of a great circle.

A small circle is one formed by a plane which does not cut the earth into two equal parts.

The formation of a small circle by cutting a sphere into unequal parts is shown in Fig. 8.

Fig. 8. Small Circle.

The great circles employed most frequently in geography are the *equator* and the *meridian circles*.

The small circles are the *parallels*.

If we divide the circumference of any circle, whether great or small, into three hundred and sixty equal parts, each part is called a degree. The one-sixtieth part of a degree is a minute; the one-sixtieth part of a minute is a second. These divisions are represented as follows: 34°, 12′, 38″; which reads, thirty-four degrees twelve minutes and thirty-eight seconds.

The Equator is that great circle of the earth which is equidistant from the poles.

Meridian Circles are great circles of the earth which pass through both poles.

The Meridian of any given place is that half of the meridian circle which passes through that place and both poles. A meridian of any place reaches from that place to both poles, and therefore is equal to one-half of a great circle, and, with the meridian directly opposite to it, forms a great circle called a meridian circle. There are as many meridians as there are places on the equator or on any parallel.

In large cities the meridian is generally assumed to pass through the principal observatory.

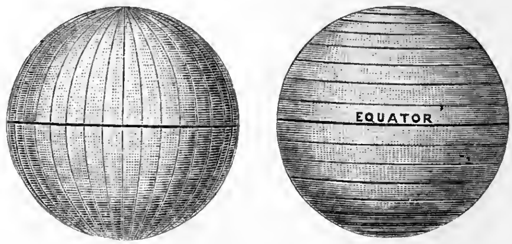


Fig. 9. Meridians and Parallels.

Parallels are small circles which pass around the earth parallel to the equator.

The meridians extend due north and south, and are everywhere of the same length; the parallels extend due east and west, and decrease in length as they approach the poles.

The Tropics are parallels which lie 23° 27′ north and south of the equator: the northern tropic is called the *Tropic of Cancer*, the southern tropic is called the *Tropic of Capricorn*.

The Polar Circles are parallels which lie 23° 27′ from each pole. The circle in the Northern Hemisphere is called the *Arctic Circle;* that in the Southern Hemisphere, the *Antarctic Circle*.

17. Latitude is distance north or south from the equator toward the poles, measured along the meridians. It is reckoned in degrees.

The meridian circles are divided into nearly equal parts by the parallels, and it is the number of these parts that occur on the meridian of any place between it and the equator which determines the value of its latitude. If we conceive eighty-nine equidistant parallels drawn between the equator and either pole, they will divide all the meridians into ninety nearly equal parts; the value of each of these parts will be one degree of latitude. Therefore, if the parallel running through a place is distant from the equator forty-five of these parts, its latitude is 45°. If more than eighty-nine parallels be drawn, the value of each part will be less than one degree.

Places north of the equator are in north latitude; those south of it are in south latitude.

Since the distance from the equator to the poles is one-fourth of an entire circle, and there are only 360° in any circle, 90° is the greatest value of latitude a place can have. Latitude 90° N. therefore corresponds to the north pole.

To recapitulate: *Latitude is measured on the meridians by the parallels.*

18. Longitude is distance east or west of any given meridian.

Places on the equator have their longitude measured along it; everywhere else longitude is measured along the parallels.

The meridian from which longitude is reckoned is called the *Prime Meridian.* Most nations take the meridians of their own capitals for their prime meridian. The English reckon from the meridian which runs through the observatory at Greenwich; the French from Paris. In the United States we reckon from Washington.

Any prime meridian circle divides all the parallels into two equal parts. A place situated east of the prime meridian is in east longitude; west of it is in west longitude.

Since there are only 180° in half a circle, the greatest value the longitude can have is 180°; for a place 181° east of any meridian would not fall within the eastern half of the parallel on which it is situated, but in the western half; and its distance, computed from the prime meridian, would be 179° west.

It is the meridians that divide the parallels into degrees; therefore *longitude is measured on the parallels by the meridians.*

19. Value of Degrees of Latitude and Longitude.—As latitude is distance measured on the arc of a meridian, the value of one degree must be the $\frac{1}{360}$th part of the circumference along that meridian, since there are only 360° in all. This makes the value of a single degree approximately equal to $69\frac{1}{6}$ miles. Near the poles the flattening of the earth causes the value of a degree slightly to exceed that of one near the equator.

The value of a degree of longitude is subject to great variation. It is equal to the $\frac{1}{360}$th part of the earth's circumference, provided the place be situated on the equator; otherwise, it is the $\frac{1}{360}$th part of the parallel passing through the place that is taken; and as the parallels decrease in size as we approach the poles, the value of a degree of longitude must likewise decrease as the latitude increases, until at either pole the longitude becomes equal to zero.

The value of a single degree of longitude on the equator, or at lat. 0°, is equal to about $69\frac{1}{6}$ miles.

At latitude	45°	it is equal to about		49	miles.
"	60°	"	"	35	"
"	80°	"	"	12	"
"	90°	"	"	0	"

Geographical Mile.—The $\frac{1}{21600}$th of the equatorial circumference, or the *one-sixtieth* of a degree of longitude at the equator, is called a nautical or geographical mile. The statute mile contains 1760 yards; the geographical or nautical mile, 2028 yards. The nautical mile is sometimes called a knot.

20. Map Projections.—The term *projection* as applied to map-drawing means the various methods adopted for representing portions of the earth's surface on the plane of a sheet of paper.

The projections in most common use are Mercator's, the orthographic, the stereographic, and the conical projections. Of these the stereographic is best adapted to ordinary geographical maps, and Mercator's to physical maps. All projections must be regarded as but approximations.

1. The *Orthographic Projection* is that by which the earth's surface is represented as it would appear to an observer viewing it from a great distance.

2. The *Stereographic Projection* is that by which the earth's surface is represented as it would appear to an observer whose eye is directly on the surface, if he looked through the earth as through a globe of clear glass, and drew the details of the surface as they appeared projected on a transparent sheet of paper stretched in front of his eye across the middle of the earth. There may be an almost infinite number of such projections, according to the position of the observer. The two stereographic projections in most common use are the *Equatorial* and the *Polar*.

Mercator's Projection represents the earth on a map in which all the parallels and meridians are straight lines.

Mercator's charts are drawn by conceiving the earth to have the shape of a cylinder instead of that of a sphere, and to be unrolled from this cylinder so as to form a flat surface. The meridians, instead of meeting in points at the north and south poles, are drawn parallel to each other. This makes them as far apart in the polar regions as at the equator, and consequently any portion of the earth's surface represented on such a chart, if situated toward the poles, will be disproportionally large. In order to avoid the distortion in the shape of the land and water areas, the distance between successive parallels is increased as they approach the poles. The dimensions of the land or water, however, are greatly exaggerated in these regions. The immediate polar regions are never represented on such charts, the poles being supposed to be at an infinite distance.

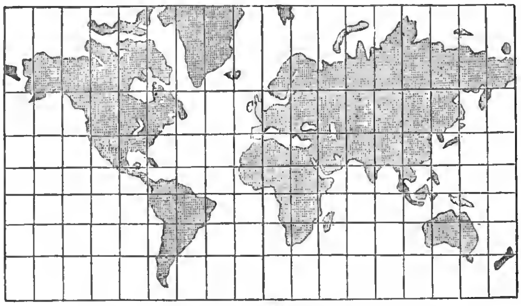


Fig. 10. The Earth on Mercator's Projection.

Mercator's charts are generally employed for physical maps, on account of the facility they afford for showing direction. The distortion they produce in the relative size of land or water areas must be carefully borne in mind, or wrong ideas of the relative size of various parts of the world will be obtained.

Mercator's charts make bodies of land and water situated near the poles *appear much larger than they really are.*

In an Equatorial Projection of the entire earth the equator passes through the middle of each hemisphere, and a meridian circle forms the borders.

In a Polar Projection of the entire earth the poles occupy the centres of each hemisphere, and the equator forms the borders.

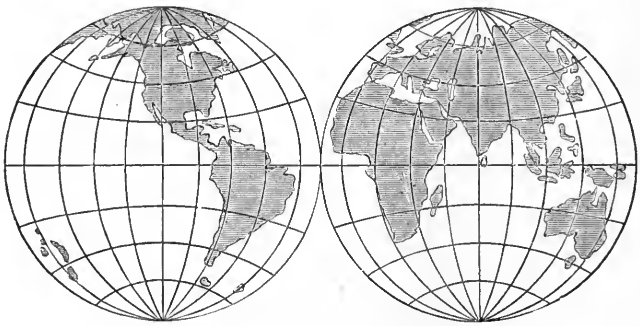


Fig. 11. The Earth on an Equatorial Projection.

In a Conical Projection the earth's surface is represented as if drawn on the frustum of a cone and afterward unrolled. This projection is suitable where only portions of the earth's surface, and not hemispheres, are to be represented. The cone is supposed to be placed so as to touch the earth at the central parallel of the country to be represented.

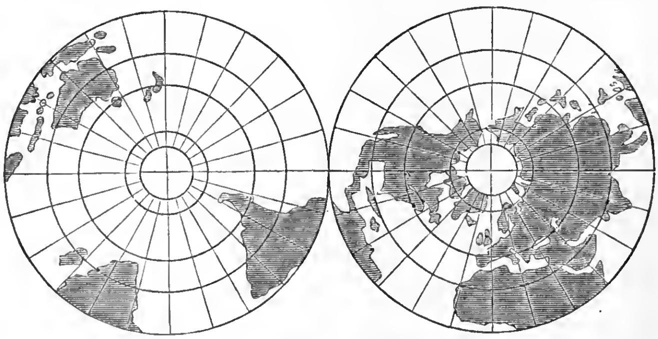


Fig. 12. The Earth on a Polar Projection.

In maps as ordinarily constructed it is not true that the upper part is north, the lower part south, the right hand east, and the left hand west, except in those on Mercator's projection. *In all maps due north and south lie along the meridians, and due east and west along the parallels, since*

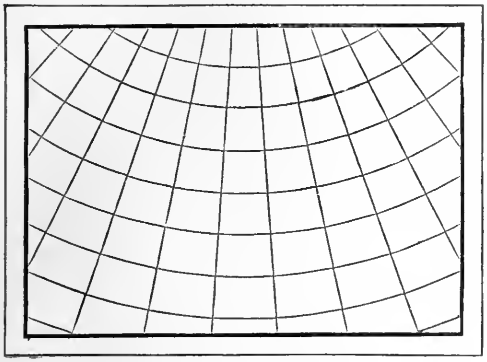


Fig. 13. The Conical Projection.

in most maps both parallels and meridians are curved lines. Therefore, in most maps due north and south and due east and west will lie along the meridians and parallels, and not directly toward the top and bottom, or the right- and left-hand side.

21. The Hemispheres.—The equator divides the earth into a *Northern* and a *Southern Hemisphere.*

The meridian of long. 20° W. from Greenwich is generally taken as the dividing-line between the *Eastern* and *Western Hemispheres.*

22. The Movements of the Earth; Rotation.—The earth turns around or spins on an imaginary diameter called its axis. This motion is called its *rotation.*

That the earth rotates from *west to east* the following consideration will show: To a person in a steam-car moving rapidly in any direction, the fences and other objects along the road will appear to be moving in the opposite direction: their motion is of course apparent, and is caused by the real motion of the car. Now, the motion of the sun and the other heavenly bodies, by which they appear to rise in the east and set in the west, is apparent, and is caused by the real motion of the earth on its axis; this motion must therefore be from *west to east.* The sun, the planets, and their satellites, so far as is known, also turn on their axes from *west to east.*

The earth makes one complete rotation in about every *twenty-four hours*—accurately, 23 hours 56 minutes 4.09 seconds. The velocity of its rotation is such that any point on the equator will travel about 1042 miles every hour. The velocity of course diminishes at points distant from the equator, until at the poles it becomes nothing.

23. Change of Day and Night.—The earth receives its light and heat from the sun, and, being an opaque sphere, only one-half of its surface can be lighted at one time. The other half is in darkness, since it is turned from the sun toward portions of space where it only receives the dim light of the fixed stars. The boundary-line between the light and dark parts is a great circle called the *Great Circle of Illumination.* Had the earth no motion either on its axis or in its orbit, that part of its surface turned toward the sun would have perpetual day, and the other part perpetual night; but by rotation different portions of the surface are turned successively toward and away from the sun, and thus is occasioned the change of *day* and *night.*

24. The Revolution of the Earth.—The earth has also a motion around the sun, called its *revolution.*

The revolution of the earth is from *west to east;* this is also true of all the planets and asteroids, and of all their satellites, except those of Uranus, and probably of Neptune.

The phrases "rotation of the earth on its axis" and "revolution in its orbit" are often used in reference to the earth's motion; but the simple words "rotation" and "revolution" are sufficient, since the first refers only to the motion on its axis, and the second only to the motion in its orbit.

The earth makes a complete revolution in 365 days 6 hours 9 minutes 9.6 seconds. This time forms what is called a *sidereal year.* The *tropical year,* or the time from one March equinox to the next, is somewhat shorter, or 365 days 5 hours 48 minutes 49.7 seconds. The latter value is the one generally given for the length of the year. It is nearly 365¼ days.

It will be found that the sum of the days in all the months of an ordinary year is only equal to 365, while the true length is approximately one-quarter of a day greater. This deficiency, which in every four years amounts to an entire day, is met by adding one day to February in every fourth or leap year. The exact time of one revolution, however, is some 11 minutes less than 6 hours. These eleven extra minutes are taken from the future, and are paid by omitting leap year every hundredth year, except that every 400 years leap year is counted. In other words, 1900 will not be a leap year, since it is not divisible by 400, but the year 2000 will be a leap year.

The length of the orbit of the earth is about 577,000,000 miles. Its shape is that of an ellipse which differs but little from a circle. The sun is placed at one focus of the ellipse, and, as this is not in the centre of the orbit, the earth must be nearer the sun at some parts of its revolution than at others.

When the earth is in that part of its orbit which is nearest to the sun, it is said to be at its *perihelion;* when in that part farthest from the sun, at its *aphelion.* The perihelion distance is about 90,259,000 miles; the aphelion distance, 93,750,000 miles. The earth reaches its perihelion about January 1st.

The earth does not move with the same rapidity through all parts of its orbit, but travels more rapidly in perihelion than in aphelion. Its mean velocity is about 19 miles a second, which is nearly sixty times faster than the speed of a cannon-ball.

25. Laplace's Nebular Hypothesis.—The uniformity in the direction of rotation and revolution of the planets has led to a very plausible supposition as to the origin of the solar system, by the celebrated French astronomer Laplace. This supposition, known as *Laplace's nebular hypothesis*, assumes that, originally, all the materials of which the solar system is composed were scattered throughout space in the form of very tenuous or nebulous matter. It being granted that this matter began to accumulate around a centre, and that a motion of rotation was thereby acquired, it can be shown, on strict mechanical principles, that a system resembling the solar system might be evolved.

As the mass contracted on cooling, the rapidity of its rotation increased. The equatorial portions bulged out through the centrifugal force, until ring-like portions separated, and, collecting in spherical masses, formed the planets. The planets in a similar manner detached their satellites. At the time of the separation of Neptune the nebulous sun must have extended beyond the orbit of this planet. The temperature requisite for so great an expansion must have been enormous.

Although a mere hypothesis, there are many facts which tend to sustain it, and it is now generally accepted.

26. The Plane of the Earth's Orbit is a perfectly flat surface so placed as to touch the earth's orbit at every point. It may be regarded as an imaginary plane of enormous extent on which the earth moves in its journey around the sun.

27. Causes of the Change of Seasons.—The change of the earth's seasons is caused by the revolution of the earth, together with the following circumstances:

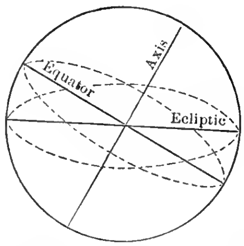


Fig. 14. Inclination of Axis to Orbit and Ecliptic.

(1.) **The inclination of the earth's axis** to the plane of its orbit. The inclination is equal to 66° 33′.

The *ecliptic* is the name given to a great circle whose plane coincides with the plane of the earth's orbit. Since the earth's axis is 90° distant from the equator, the plane of the ecliptic must be inclined to the plane of the equator 90° minus 66° 33′, or 23° 27′.

The mere revolution of the earth would be unable to produce a change of seasons, unless the earth's axis were inclined to the plane of its orbit. If, for example, the axis of the earth stood perpendicularly on the plane of its orbit, the sun's rays would so illumine the earth that the great circle of illumination would always be bounded by some meridian circle. The days and nights would then be of equal length, and the distribution of heat the same throughout the year. Under these circumstances there could be no change of seasons, since the sun's rays would always fall perpendicularly on the same part of the earth: on the equator.

(2.) **The Constant Parallelism of the Earth's Axis.**—During the revolution of the earth, its axis always points to nearly the same place in the heavens: nearly to the north star. It is therefore always parallel to any former position.

Unless the earth's axis were constantly parallel to any former position, the present change of seasons would not exist.

On account of the spherical form of the earth, only a small part of its surface can receive the vertical rays of the sun at the same time. This part can be regarded as nearly a point; and since only one-half of the earth is lighted at any one time, the great circle of illumination must extend 90° in all directions from the point which receives the vertical rays. By rotation all portions of the surface situated anywhere within the tropics in the same latitude, at some time or another during the day, are turned so as to receive the vertical rays of the sun, and consequently, the portion so illumined has the form of a ring or zone. Other things being equal, this zone contains the hottest portions of the surface, the heat gradually diminishing as we pass toward either pole.

On account of the inclination of its axis, the earth receives the vertical rays of the sun on new portions of its surface every day during its revolution; and *it is because different portions of the surface are constantly being turned toward the sun that the change of seasons is to be attributed.*

As the earth changes its position in its orbit, the sun's rays fall vertically on different parts of the surface, so that during the year one part or another of the surface within 23° 27′ on either side of the equator receives the vertical rays.

The astronomical year begins on the 20th of March, and we shall therefore first consider the position of the earth in its orbit at that time.

An inspection of Fig. 15 will show that at this time the earth is so turned toward the sun *that the vertical rays fall exactly on the equator.* The great circle of illumination, therefore, reaches to the poles, and the days and nights are of an equal length all over the earth. This time is called the March equinox. *Spring then begins in the Northern Hemisphere, and autumn in the Southern.* This is shown more clearly in Fig. 16, which represents the relative positions of the illumined and non-illumined portions at that time.

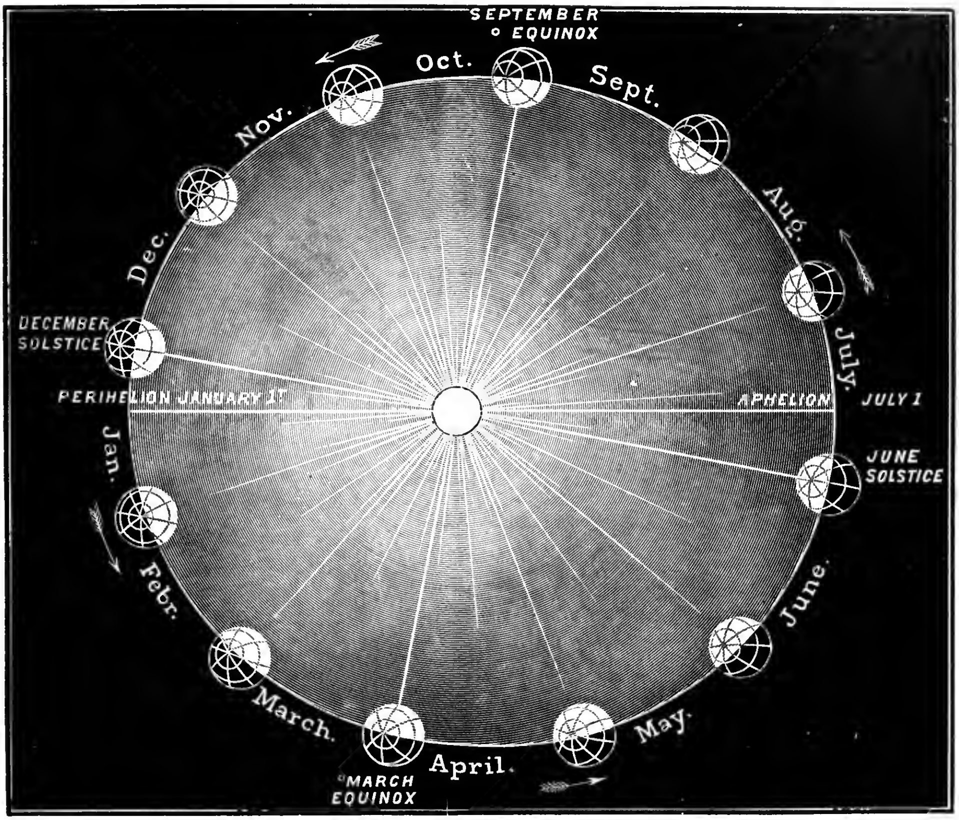


Fig. 15. The Orbit of the Earth, showing the Change of Seasons.

As the earth proceeds in its orbit, the inclination of the axis causes it to turn the Northern Hemisphere more and more toward the sun. The vertical rays, therefore, fall on portions farther and farther north until, on the *21st of June, the vertical rays reach their farthest northern limit, and fall directly on the Tropic of Cancer*, 23° 27′ N., when the sun is said to be at its summer *solstice.*

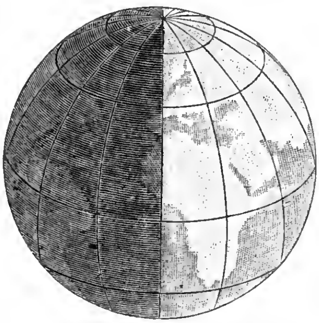


Fig. 16. The Earth at an Equinox.

Since the portions receiving the vertical rays of the sun are now on the Tropic of Cancer, the light and heat must extend in the Northern Hemisphere to 23° 27′ beyond the north pole, or to the Arctic Circle; while in the Southern Hemisphere they must fall short of the south pole by the same number of degrees, or reach to the Antarctic Circle. *The Northern Hemisphere then begins its summer, and the Southern its winter.*

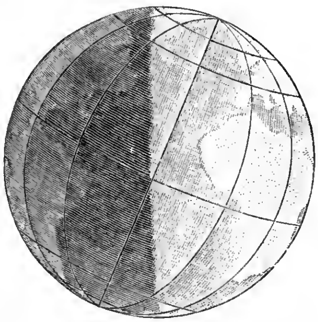


Fig. 17. The Earth at the Summer Solstice.

The relative positions of the illumined and non-illumined portions of the earth at the summer solstice are more clearly shown in Fig. 17. Here, as is shown, the great circle of illumination extends in the Northern Hemisphere as far over the pole as the Arctic Circle.

After the 21st of June the Northern Hemisphere is turned less toward the sun, and the vertical rays continually approach the equator, all the movements of the preceding season being reversed, until *on the 22d of September, the time of the September equinox, the equator again receives the vertical rays,* the great circle of illumination again coinciding with the meridian circles. The earth has now moved from one equinox to another, and has traversed one-half of its orbit. *The Southern Hemisphere then begins its spring, the Northern its autumn.*

From the 22d of September until the 20th of March, while the earth moves through the other half of its orbit, the same phenomena occur in the Southern Hemisphere that have already been noticed in the Northern. Immediately after the 22d of September the inclination of the axis causes the earth to be so turned toward the sun that its rays begin to fall south of the equator; and, as the earth proceeds in its orbit, the Southern Hemisphere is turned more and more toward the sun, and the vertical rays fall farther and farther toward the pole. This continues until the *21st of December, when the rays fall vertically on the Tropic of Capricorn, and the December solstice is reached.* The great circle of illumination now extends beyond the south pole as far as the Antarctic Circle, but falls short of the north pole 23° 27′, reaching only the Arctic Circle. *Summer then commences in the Southern Hemisphere, and winter in the Northern.*

After the 21st of December the Southern Hemisphere is turned less and less toward the

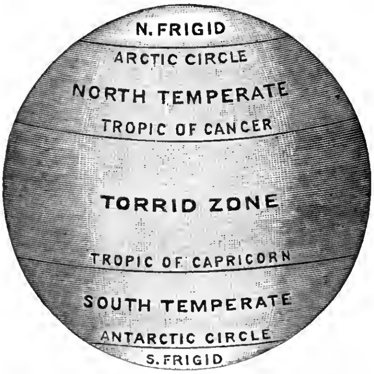


Fig. 18. Mathematical Climatic Zones.

sun, and the part receiving the vertical rays approaches the equator, until on the 20th of March the equator again receives the vertical rays, and, with the March equinox, spring commences in the Northern Hemisphere, and with it a new astronomical year.

28. Mathematical Zones.—The Torrid Zone.—That belt of the earth's surface which lies between the tropics is called the *Torrid Zone.* During one time or another throughout the year every part of its surface receives the vertical rays of the sun.

The Temperate Zones are included between the tropics and the polar circles. The northern zone is called the *North Temperate Zone,* and the southern zone, the *South Temperate Zone.*

The Polar Zones are included between the polar circles and the poles. The northern zone is called the *North Frigid Zone,* and the southern zone, the *South Frigid Zone.*

These zones, which are separated by the parallels of latitude, are generally termed the *astronomical* or *mathematical zones* to distinguish them from others called *physical zones,* which are bounded by the lines of mean annual temperature.

It will be noticed that the distance of the tropics from the equator and of the polar circles from the poles is 23° 27′, or the value of the inclination of the plane of the ecliptic to the plane of the equator.

29. Length of Day and Night.—Whenever more than half of either the Northern or Southern Hemisphere is illumined, the great circle of illumination will divide the parallels unequally, and the length of the daylight in that hemisphere will exceed that of the night in proportion as the length of the illumined part, measured along any of the parallels, exceeds that of the dark part.

The length of daylight or darkness may exceed that of one complete rotation of the earth. The great circle of illumination may at times pass over the poles as far beyond them as 23° 27′; and places situated within this limit may remain during many rotations exposed to the rays of the sun.

A little consideration will show that the longest day must occur at the poles, since the poles must continue to receive the sun's rays from the time they are first illumined at one equinox until the sun passes through a solstice and returns to the other equinox. Nowhere, outside the polar circles, will the length of daylight exceed one entire rotation of the earth.

The length of the longest day at the equator, latitude 0°, is 12 hours.

Of the longest day at latitude 66° 33′ is 24 hours.

Of the longest day at latitude 67° 20′ is one month.

Of the longest day at latitude 73° 6′ is three months.

Of the longest day at the poles, latitude 90°, is six months.

SYLLABUS.

There are three kinds of geography—Mathematical, Political, and Physical.

Physical Geography treats of Land, Water, Air, Plants, and Animals.

Geography deals mainly with the earth as it is; geology mainly with the earth as it was.

The earth continues its motion around the sun in consequence of its inertia.

The distant stars are balls of fire like our sun, and probably have worlds resembling ours revolving around them.

The sun and the bodies that revolve around it constitute the solar system.

The sun is about 1,300,000 times larger than the earth.

The sun is a body heated to luminosity, and gives out or emits light and heat like any other highly-heated body.

The shape of the earth is that of an oblate spheroid whose equatorial diameter is about 26 miles longer than its polar. That the earth is round and not flat is proved —1st, by the appearance of approaching or receding objects; 2d, by the circular shape of the horizon; 3d, by the circular shape of the earth's shadow; 4th, by actual measurement; and 5th, by the shape of the great circle of illumination.

The earth's diameter is nearly 8000 miles, its circumference not quite 25,000 miles, and its area about 197,000,000 square miles.

The imaginary circles used in geography are the Equator, the Meridian Circles, and the Parallels.

Latitude is measured on the meridians by the parallels.

The greatest number of degrees of latitude a place can have is 90°; the greatest of longitude, 180°. The latitude at the equator is 0° N. or S. The longitude at the poles or on the prime meridian is 0° E. or W.

Longitude is measured on the equator, or on the parallels, by the meridians.

Maps are drawn on different projections: the Equatorial, the Polar, and Mercator's projections are in most general use. A Mercator's projection causes places near the poles to appear larger than they really are.

On all maps due north and south lies along the meridians; due east and west, along the parallels: when these are curved lines, the top and bottom of the map will not always represent north and south, nor the right and left hand east and west.

The inclination of the earth's axis to the plane of its orbit, and the constant parallelism of the axis with any former position, together with the revolution around the sun, cause the change of seasons.

The astronomical year begins March 20th.

On the 20th of March and on the 22d of September the days and nights are of equal length all over the earth. From the 20th of March the days increase in length in the Northern Hemisphere until the 21st of June, when they attain their greatest length; they then decrease until the 22d of September, when they again become equal.

The Torrid Zone is the hottest part of the earth, because, during one time or another throughout the year, every part of its surface receives the vertical rays of the sun.

REVIEW QUESTIONS.

The Solar System.

How does the principle of inertia apply to the earth's motion around the sun?

What do you understand by the solar system?

Describe the earth's position in the solar system. Which of the planets are between the earth and the sun? Which are beyond the orbit of the earth?

How does the size of the sun compare with that of the earth?

Are any of the distant stars larger than our sun?

What is a satellite? Which of the planets have satellites?

Explain the cause of the circular shape of the earth's orbit.

In what part of space is the solar system?

Has our sun any motion through space?

Enumerate the proofs of the rotundity of the earth.

State accurately the length of the equatorial diameter of the earth; of its polar diameter; of its circumference. What is its area?

How many times heavier is the earth than an equally large globe of water?

Imaginary Circles.

Define great and small circles. Name the circles most commonly used in geography.

What do you understand by latitude? How is latitude reckoned? Of what use is latitude in geography? Why can the value of the latitude never exceed 90°? Of what use are meridians and parallels in measuring latitude?

What do you understand by longitude? How is longitude reckoned? Of what use is longitude in geography? Why can its value never exceed 180°? Of what use are meridians and parallels in measuring longitude?

Where is the value of a degree of latitude the greatest? Of a degree of longitude? Why?

What effect has a Mercator's chart on the appearance of bodies of land or water in high northern or southern latitudes?

What is an equatorial projection? A polar projection? A conical projection? What is the position of the poles in an equatorial projection? In a polar projection?

Movements of the Earth.

Prove that the earth turns on its axis from west to east.

Explain the cause of the change of day and night.

Define a sidereal year; a tropical year. Which value is generally taken for the length of the civil year?

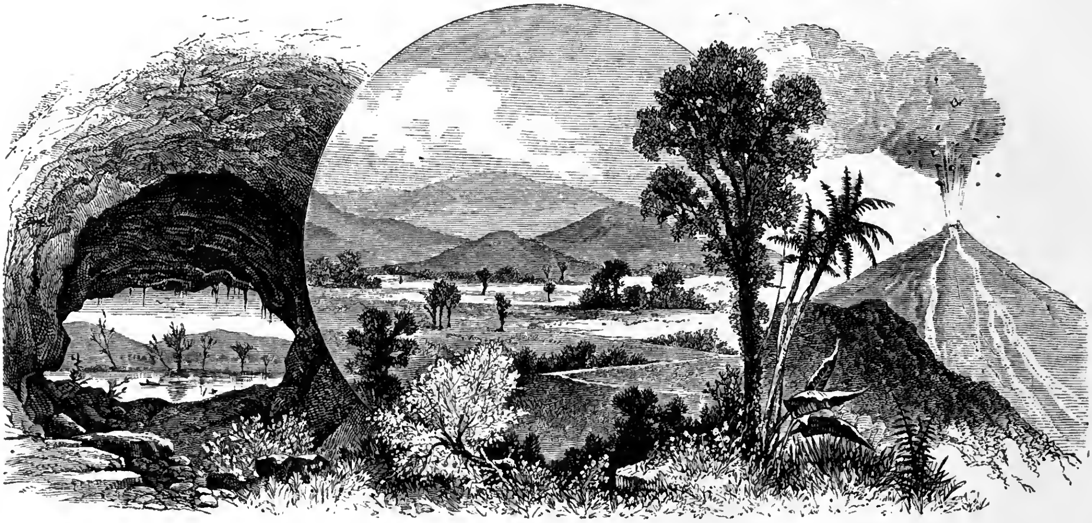
Describe Laplace's nebular hypothesis.

Enumerate the causes which produce the change of seasons.

On what days of the year will the sun's rays fall vertically on the equator? On what days will its rays fall vertically on the Tropic of Cancer? On the Tropic of Capricorn?

PART II.

THE LAND.



ALTHOUGH water occupies much the larger portion of the earth's surface, yet, when compared with the entire volume of the globe, its quantity is comparatively insignificant; for the mean depth of the ocean probably does not exceed two and one-third miles, and underneath this lies the solid crust, with its heated interior.

The crust and heated interior are composed of a variety of simple and compound substances. Simple or elementary substances are those which have never been separated into components. Compound substances are those which are composed of two or more simple or elementary substances combined under the influence of the chemical force.

SECTION I.

THE INSIDE OF THE EARTH.

CHAPTER I.

The Heated Interior.

30. The Proofs of the Earth's Original Fluidity or fused condition through heat are—

(1.) **Its Spherical Shape,** which is the shape the earth would have taken had it been placed in space when in a melted condition. This is the shape of nearly all the heavenly bodies.

(2.) **The fact that the rocks which were first formed** give evidence by their appearance of having been greatly heated. These rocks are generally highly crystalline.

(3.) **The general climate of the earth** during the geological past was much warmer than at present.

Very little of the internal heat now reaches the surface. According to Poisson, all that escapes would raise the mean annual temperature only $\frac{1}{17}$th of a degree Fahr.

31. Laplace's Nebular Hypothesis agrees very well with the idea of a former igneous fluidity, since, at the time of its separation from the nebulous sun, the earth must have had a temperature sufficient not only to fuse, but even to volatilize, most of its constituents.

32. Proofs of a Present Heated Interior.—The following considerations show that the inside of the earth is still highly heated:

(1.) **The deeper we penetrate the crust**, the higher the temperature becomes. Moreover, the rate of increase, though varying in different localities with the character of the materials of the crust, is nearly uniform over all parts of the surface, *the average value of the increase being 1° Fahr. for every 55 feet of descent.*

This would seem to indicate that the entire inside of the earth is heated, and that the heat increases as we go toward the centre.

We cannot, however, estimate the thickness of the crust from this fact—

1. Because we have never penetrated the crust more than a few thousand feet below the level of the sea, and therefore we do not know that this rate of increase of temperature continues the same;

2. Even if it did continue uniform, since the melting-point of solids increases with the pressure, we do not know what allowance should be made for this increase.

(2.) **In all latitudes prodigious quantities of melted rock** escape from the interior through the craters of volcanoes. The interior, therefore, must be hot enough to melt rock.

33. Condition of the Interior.—We do not know the condition of the material which fills the interior of the earth. It might be supposed, since rock escapes from the craters of volcanoes in a fluid or molten condition, that the interior is filled with molten matter; but this is not necessarily so, since the enormous pressure to which the interior is subjected would probably be sufficient to compress it into a viscous or pasty mass, or, possibly, even to render it solid. The lava which issues from the crater of a volcano is necessarily more mobile than the interior of the earth; for, coming, as it does, from great depths, it must grow more and more liquid as it approaches the surface and is thus relieved of its pressure. Indeed, the most viscous rock conceivable, if highly heated when ejected from profound depths, would become comparatively fluid on reaching the surface.

34. Views Concerning the Condition of the Interior.—Considerable difference of opinion exists as to the exact condition of the interior of the earth. The following opinions may be mentioned:

(1.) That the earth has a solid centre and crust, with a heated or pasty layer between.

(2.) That the crust is solid, but the interior highly heated, so as to be in a fused or pasty condition.

(3.) That the earth is solid throughout, but highly heated in the interior.

Of the above views, the second is perhaps the most tenable, and will be adopted as serving in the simplest manner to explain the phenomena of the earth arising from the presence of a highly heated interior. Admitting the crust to be sufficiently thin, and in such a condition as to permit of but a small degree of warping, then all the phenomena can be satisfactorily explained.

35. Thickness of the Crust.—We cannot assign a definite limit to the thickness of the crust, since the portions that are solid from having cooled, most probably pass insensibly into those that are nearly solid from the combined influence of loss of heat and increasing pressure. It seems probable that the portion solidified by cooling is thin, when compared with the whole bulk of the earth; in other words, the heated interior lies comparatively near the surface.

36. Effects of the Heated Interior.—As the crust loses its heat it shrinks or contracts, and, growing smaller, the materials of the interior are crowded into a smaller space, and an enormous force is thus exerted, both on the interior and on the crust itself, tending either to change the shape of the crust, to break it, or to force out some of the interior. The following phenomena are therefore caused by the contraction of the crust:

(1.) Volcanoes;

(2.) Earthquakes;

(3.) Non-volcanic igneous eruptions;

(4.) Gradual elevations or subsidences of the crust.

CHAPTER II.

Volcanoes.

37. Volcanoes.—One of the most striking proofs of the existence of a heated interior is the ejection of enormous quantities of melted rock through openings in the crust.

A volcano is a mountain, or other elevation, through which the materials of the interior escape to the surface. The opening is called the *crater*, and may be either on the top or on the sides of the mountain.

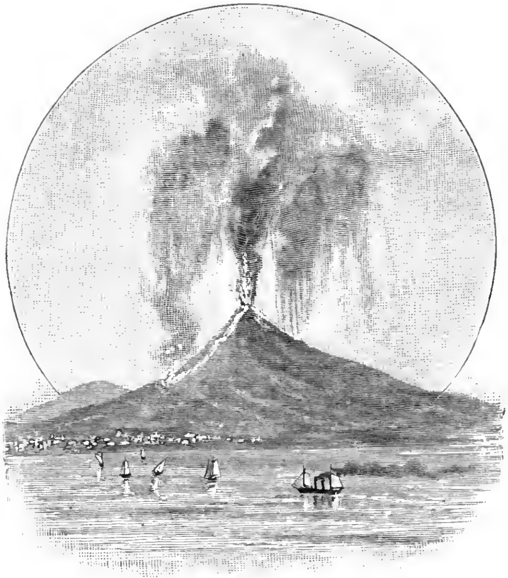


Fig. 19. An Eruption of Mount Vesuvius.

38. Peculiarities of Craters.—The crater, as its name indicates, is *cup-shaped.* The rim, though generally entire, is sometimes broken by the force of the eruption, as in Mount Vesuvius, where the eruption in 79 A. D.—the first on record—blew off the northern half of the crater. The material thus detached, together with the showers of ashes and streams of lava, completely buried the cities of Herculaneum and Pompeii, situated near its base.

The crater is often of immense size. Mauna Loa, on the island of Hawaii, has two craters—one on the summit, and the other on the mountain-side, about 4000 feet above the sea. The latter—Kilauea—is elliptical in shape, and about 7½ miles in circumference; its area is nearly 4 square miles, and its depth, from 600 to 1000 feet.

Volcanic mountains are of somewhat different shapes, but near the crater the *conical* form predominates, and serves to distinguish these mountains as a class. The shape of the volcanic cone is caused by the ejected materials accumulating around the mouth of the crater in more or less concentric layers.

39. The ejected materials are mainly as follows:

(1.) **Melted Rock, or Lava.**—Lava varies, not only with the nature of the materials from which it was formed, but also with the conditions under which it has cooled, and the quantity of air or vapor entangled in it. Though generally of a dark gray, it occurs of all colors; and its texture varies from hard, compact rock to porous, spongy material that will float on water.

When just emitted from the crater, ordinary lava flows about as fast as molten iron would on the same slope. On steep mountains, near the crater, the lava, when very hot, may flow faster than a horse can gallop; but it soon cools, and becomes covered with a crust that greatly retards the rapidity of its flow, until its motion can only be determined by repeated observations.

At Kilauea, jets of very liquid lava are sometimes thrown out, which, falling back into the crater, are drawn out by the wind into fine threads, thus producing what the natives call Pélé's hair, after their mythical goddess.

The volume of the ejected lava is often very great. Volcanic islands are generally formed entirely by lava streams. Hawaii and Iceland were probably formed entirely of lava emitted from numerous volcanic cones.

(2.) **Ashes or Cinders.**—These consist of minute fragments of lava that are ejected violently from the crater; at night they appear as showers of brilliant sparks. When they fall directly back on the mountain, they aid in rearing the cone. More frequently, they are carried by the wind to points far distant. The destructive effects of volcanic eruptions are caused mainly by heavy showers of ashes. The ashes, when exceedingly fine, form what is called *volcanic dust.*

At the beginning of an eruption large fragments of rock are sometimes violently thrown out of the crater.

(3.) **Vapors, or Gases.**—The vapor of water often escapes in great quantities from the crater, especially at the beginning of the eruption. On cooling, it condenses and forms dense clouds, from which torrents of rain fall. These clouds, lighted by the glowing fires beneath, appear to be actually burning, and thus give rise to the erroneous belief that a volcano is a burning mountain. To the condensation of this vapor is probably to be ascribed the lightning which often plays around the summit of the volcano during an eruption. Besides the vapor of water, various gases escape, of which sulphurous acid is the most common.

When a large quantity of rain mingles with the ashes, torrents of mud are formed, which move with frightful velocity down the slopes of the mountain, occasioning considerable damage. During the eruption of Galungung, in Java, more than one hundred villages were thus destroyed. The rock that is formed by the hardening of volcanic mud is called *tufa.*

40. The Inclination of the Slopes of the volcanic cones depends on the nature of the material of which they are formed. Where *lava* is the main ingredient, the cone is *broad and flat.* The inclination of a lava cone ranges from 3° to 10°,

Fig. 20. Lava Cone. Inclination from 3° to 10°.

according to the liquidity of the lava. A very stiff lava will form a much steeper cone.

Ashes and cinders form steeper cones, whose inclinations range from 30° to 45°.

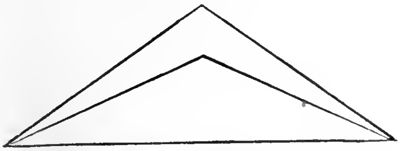


Fig. 21. Ash Cone. Inclination from 30° to 45°.

The sides of volcanic cones are often rent during the eruption, and the fissures filled with lava, which hardens and forms rocky ribs called *dykes.* Sometimes the central cone becomes choked, and secondary or parasitic cones are formed.

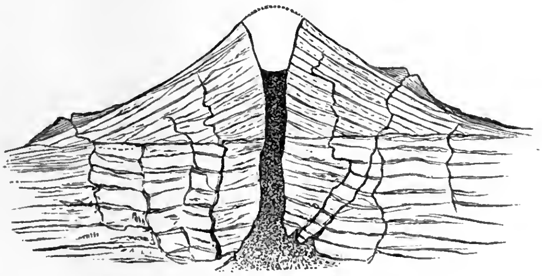


Fig. 22. Volcanic Dykes and Parasitic Cones.

41. The Cause of Volcanic Eruptions.—As the heated earth cools and the crust contracts, the materials of the interior are crowded into a smaller space, and an enormous force is exerted, which causes portions of the interior to rise from profound depths and escape through openings in the crust. These openings form the craters of volcanoes.

The principal agency, therefore, which brings up the heated material from great depths is *the contraction of the crust on cooling.* The melted rock thus brought into the volcano may escape—

(1.) **By the pressure of highly-heated gases or vapors,** mainly that of water, which throws the lava explosively from the crater.

(2.) **By the pressure exerted by a column of liquid lava.** Before the lava can run over the edge of the crater near the top of the mountain, the pressure caused by its weight becomes so great that the sides of the mountain are broken, and the lava escapes quietly from a lower opening.

42. Other Explanations of Volcanic Action.—The above theory of volcanic action is not accepted by all scientists. Instead of an originally heated globe that has not yet completely cooled, it is asserted by some that heat is now being produced either by some chemical means, such as oxidation or hydration, or by a mechanical crushing of deep-seated strata. These explanations assume that the seat of the lava is not the entire interior of the earth, but that it is purely local, existing in comparatively shallow basins or reservoirs not far from the surface. The peculiarities of distribution of volcanoes would appear to disprove the latter assumption.

43. Volcanic Eruptions may be divided into two classes: explosive and non-explosive.

Explosive eruptions are caused by the sudden formation of highly-heated vapors.

In boiling water, drops are thrown from the surface by the bursting of bubbles of steam. This action is similar to that of explosive volcanic eruptions. When the liquid is viscous, like tar, the escaping vapor accumulates in large bubbles, the bursting of which scatters the material in all directions.

On account of the great viscidity of some lavas, the evolved gases accumulate until considerable force is acquired. At Kilauea, liquid jets are thrown upward to the height of 40 feet. With very viscid lavas, like those of Vesuvius, bubbles of enormous size are suddenly formed, which burst with almost incredible force. Cases are on record in which it is estimated the ashes were projected 10,000 feet above the mouth of the crater.

Non-explosive eruptions are caused by the pressure of a column of liquid lava.

In non-explosive eruptions the lava escapes quietly through a fissure which opens in the mountain's side by the pressure exerted by the column of liquid lava in the crater.

Since a column of lava 500 feet high exerts a pressure of about 625 pounds to the square inch, when the mountain is high the pressure against the sides of the crater may be sufficient to rend the solid rock.

Vesuvius is an example of an explosive eruption; Kilauea and Etna, of non-explosive eruptions.

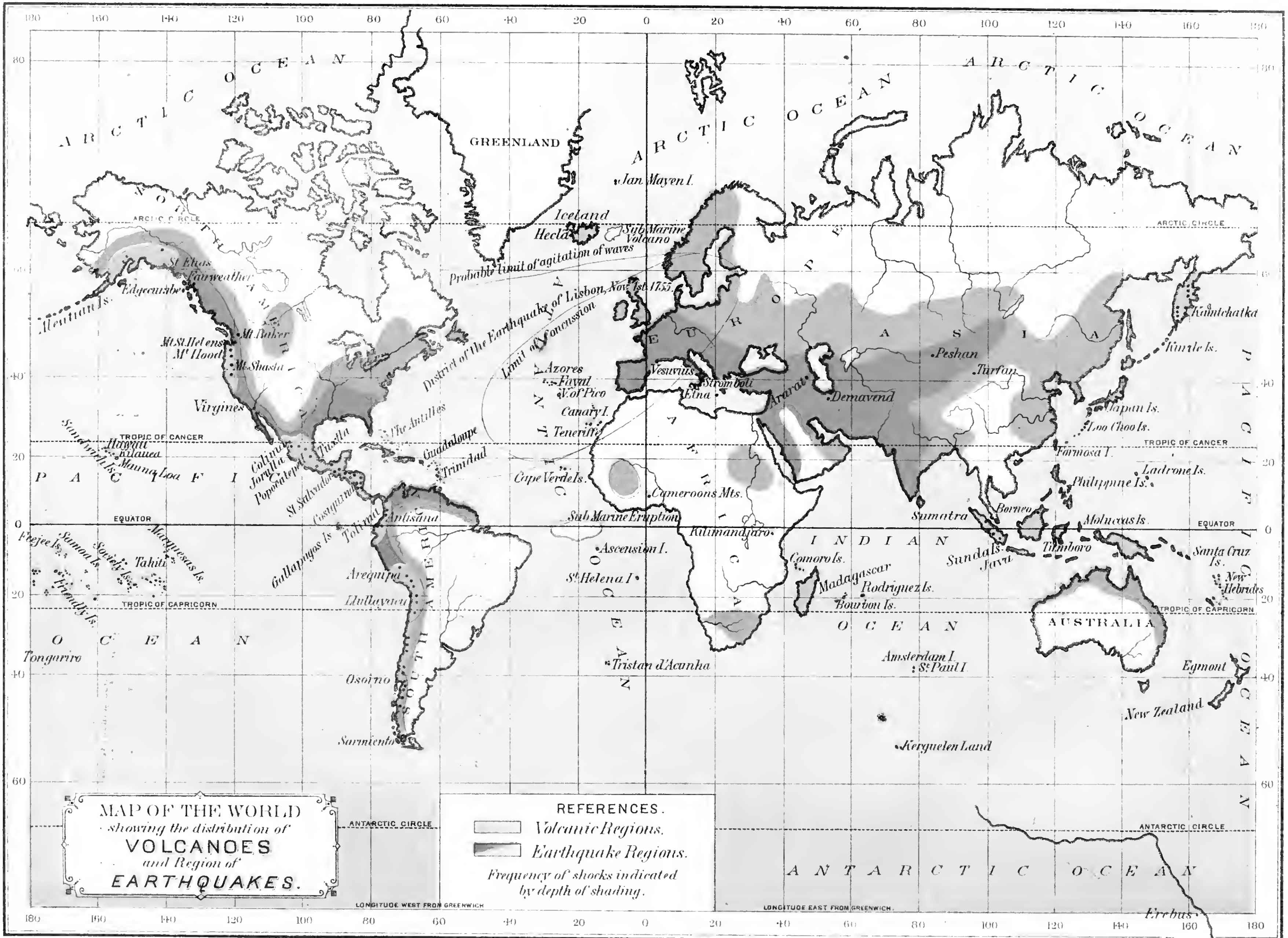
Volcanic mountains whose eruptions are non-explosive are generally *high;* the lava can thus accumulate in the crater until it forces its way through fissures below. Volcanic mountains whose eruptions are explosive are generally *low.*

Volcanoes are of common occurrence at the bottom of the ocean. These are called *submarine volcanoes.* During eruptions their cones sometimes project above the water; but they generally soon afterward disappear.

44. Active and Extinct Volcanoes.—Volcanoes may be classified as active and extinct.

Active Volcanoes are those which emit smoke, vapor, ashes, or lava from the crater.

By an active volcano we do not mean one that is continually in a state of eruption—ejecting ashes and lava—but one from which at least smoke or vapor is escaping. The crater may at any time become permanently choked, when the volcano becomes *extinct.* It may, however, open at any time, after extended intervals of rest, when the volcano again becomes active.


MAP OF THE WORLD
showing the distribution of
VOLCANOES
and Region of
EARTHQUAKES.
REFERENCES.
Volcanic Regions.
Earthquake Regions.
Frequency of shocks indicated by depth of shading.
ARCTIC OCEAN
PACIFIC OCEAN
ATLANTIC OCEAN
INDIAN OCEAN
ANTARCTIC OCEAN
GREENLAND
NORTH AMERICA
SOUTH AMERICA
EUROPE
ASIA
AFRICA
AUSTRALIA
ARCTIC CIRCLE
TROPIC OF CANCER
EQUATOR
TROPIC OF CAPRICORN
ANTARCTIC CIRCLE
LONGITUDE WEST FROM GREENWICH
LONGITUDE EAST FROM GREENWICH
Jan Mayen I.
Iceland
Hecla
Sub Marine Volcano
Probable limit of agitation of waves
District of the Earthquake of Lisbon, Nov. 1st 1755.
Limit of Concussion
Azores
Fayal
V. of Pico
Canary I.
Teneriffe
Cape Verde Is.
Sub Marine Eruption
Ascension I.
St. Helena I.
Tristan d'Acunha
Vesuvius
Stromboli
Etna
Ararat
Demavend
Peshan
Turfan
Cameroons Mts.
Kilimandjaro
Comoro Is.
Madagascar
Rodriguez Is.
Bourbon Is.
Amsterdam I.
St. Paul I.
Kerguelen Land
Kamtchatka
Kurile Is.
Japan Is.
Loo Choo Is.
Formosa I.
Ladrone Is.
Philippine Is.
Borneo
Sumatra
Sunda Is.
Java
Timboro
Moluccas Is.
Santa Cruz Is.
New Hebrides
Egmont
New Zealand
Erebus
Terror
Aleutian Is.
Edgecumbe
St. Elias
Fairweather
Mt. Baker
Mt. St. Helens
Mt. Hood
Mt. Shasta
Virgines
Sandwich Is.
Hawaii
Kilauea
Mauna Loa
Colima
Jorullo
Popocatepetl
Tuxtla
St. Salvador
Cosiguina
The Antilles
Guadaloupe
Trinidad
Tolima
Antisana
Gallapagos Is.
Arequipa
Llullayacu
Osorno
Sarmiento
Marquesas Is.
Tahiti
Society Is.
Samoa Is.
Feejee Is.
Friendly Is.
Tongariro

45. The number of volcanoes is not accurately known. The best authorities estimate it at about 672, of which 270 are active. Of the latter, 175 are *on islands,* and 95 are on the *coasts of the continents.*

46. Regions of Volcanoes.—The principal volcanic regions of the earth are—*

(1.) **Along the Shores of the Pacific**, where an immense chain of volcanoes, with but few breaks, encircles it in a huge "*Sea of Fire.*"

On the Eastern Borders, in the Andean range, are the volcanic series of Chili, Bolivia, and Ecuador; those of Central America and Mexico; in the United States are the series of the Sierra Nevada and Cascade ranges and of Alaska; and finally, connecting the system with Asia, the volcanic group of the Aleutian Islands.

On the Western Borders volcanoes occur in the following districts: the Kamtchatkan Peninsula, with its submerged ranges of the Kurile Islands; the Japan, the Loo Choo, and the Philippine Islands; the Moluccas; the Australasian Island Chain, terminating in New Zealand; and finally, nearly in a line with these, the volcanoes of Erebus and Terror on the Antarctic continent.

(2.) **In the Islands of the Pacific.**—Volcanic activity is not wanting over the bed of the Pacific. The Sandwich Islands, the Society Group, the Marquesas, Friendly Islands, New Hebrides, Ladrones, and many others, are volcanic.

(3.) **Scattered over the Seas that divide the Northern and Southern Continents, or in their vicinity,** viz.: in the neighborhood of the Caribbean Sea, in the Mediterranean and Red Seas, and in the Pacific and Indian Oceans between Asia and Australia.

In the neighborhood of the Caribbean Sea.—This region includes the two groups of the Antilles in the Caribbean Sea, and the Gallapagos Islands in the Pacific Ocean.

In the neighborhood of the Mediterranean and Red Seas.—This region includes the volcanoes of the Mediterranean and its borders, those of Italy, Sicily, the Grecian Archipelago, of Spain, Central France, and Germany, together with those near the Caspian and Red Seas.

Between Asia and Australia.—This region includes the Sunda Islands, Sumatra, Java, Sumbawa, Flores, and Timor, which contain numerous craters. In Java there are nearly 50 volcanoes, 28 of which are active, and there are nearly as many in Sumatra. There are 109 volcanoes in the small islands near Borneo.

(4.) **In the Northern and Central Parts of the Atlantic Ocean.**

All the islands in the deep ocean which do not form a part of the continent are volcanic; as, for example, the island of St. Helena, Ascension Island, the Cape Verdes, the Canaries, the Azores, and Iceland. The Cameroons Mountains, on the African coast near the Gulf of Guinea, together with some of the islands in the gulf, are volcanic.

(5.) **In the Western and Central Parts of the Indian Ocean.**

Volcanoes are found in Madagascar and in the adjacent islands. They also occur farther south, in the island of St. Paul and in Kerguelen Land, and in Kilimandjaro, near the eastern coast of Africa.

47. Submarine Volcanoes.—From the difficulty in observing them, submarine volcanoes are not so well known as the others. The following regions are well marked:

In the Mediterranean Sea, near Sicily and Greece.

Near the island of Santorin the submarine volcanic energy is intense. It has been aptly described as a region "Where isles seem to spring up like fungi in a wood."

In the Atlantic Ocean; off the coast of Iceland; near St. Michael, in the Azores; and over a region in the narrowest part of the ocean between Guinea and Brazil.

In the Pacific Ocean; near the Aleutian Islands, where two large mountain-masses have risen from the water within recent time. Near the Japan Islands, where, about twenty-one centuries ago, according to native historians, Fusi Yama, the highest mountain in Japan, rose from the sea in a single night.

In the Indian Ocean, the island of St. Paul, in the deep ocean between Africa and Australia, exhibits signs of submarine activity.

48. Peculiarities of Distribution.—Nearly all volcanoes are found near the shores of continents or on islands.

The only exceptions are found in the region south of the Caspian Sea, and in that of the Thian Shan Mountains. As volcanoes are but openings in the earth's crust which permit an escape of materials from the pasty interior, they will occur only *where the crust is weakest.* This will be on the borders of sinking oceans, in the lines of fracture formed by the gradual separation of the ocean's bed from the coasts of the continent. The floor of the ocean in all latitudes is covered with a layer of quite cold water, so that the difference in the amount of the contraction will in general be most marked on the borders of the oceans or on the edges of the continents.

In most regions the volcanoes lie along lines

* We follow mainly the classification of Dana.

more or less straight. Lines joining such a series may be considered as huge cracks in the crust, the volcanic phenomena occurring in their weakest places.

The frequent occurrence of volcanoes in mountainous districts is caused by the crust being broken and flexed, so as to admit of an easy passage for the molten rock.

Where one system of fissures crosses another the crust becomes weak, the openings numerous, and the volcanic activity great. The two antipodal points of the Antilles and the Sunda Islands are excellent examples, and are the most active volcanic regions on the earth.

Efforts have been made to show some connection between certain states of the weather and periods of volcanic activity; but, so far, these have amounted to mere predictions of coming changes, based on observations of the direction of upper currents of air from the clouds of ashes or smoke ejected by the volcano. No law of periodicity of eruption has, as yet, been discovered.

49. Other Volcanic Phenomena:

Mud Volcanoes are small hillocks that emit streams of hot mud and water from their craters, but *never molten rock.* They are found in volcanic regions.

Solfataras are places where sulphur vapors escape and form incrustations. They occur in volcanic regions.

Geysers are sometimes ranked with volcanic phenomena. They are described under Hot Springs.

CHAPTER III.

Earthquakes.

50. Earthquakes are shakings of the earth's crust, of degrees varying in intensity from scarcely perceptible tremors to violent agitations that overthrow buildings and open huge fissures in the ground. They may therefore be divided into two classes:

(1.) A shaking movement without any permanent change in the surface;

(2.) A shaking movement accompanying an uplift or subsidence.

An earthquake is sometimes called a *seismic* shock.

51. Facts concerning Earthquakes.—A careful study of earthquakes appears to establish the following facts:

(1.) **The place or origin** of the shock is not deep-seated or far below the earth's surface, but is near the surface, probably never deeper than thirty miles, and often much less.

Fig. 23. Fissures produced by the Charleston Earthquake of 1886.

(2.) **The area of disturbance** depends not only on the energy of the shock, but also on the depth of its origin below the surface: the deeper the origin, the greater the area.

(3.) **The shape of the origin** is generally that of a line, often many miles in length.

(4.) **The direction of the motion** at the surface is nearly upward over the origin, and more inclined as the distance from the origin increases.

(5.) **The shape of the area** of disturbance depends on the nature of the materials through which the wave is moving. If these are of nearly uniform elasticity in all directions, the area is nearly circular; if more elastic in one direction than in another, the area is irregular in shape.

52. The Varieties of Earthquake Motion at the Earth's Surface are—

(1.) **A wave-like motion,** in which the ground rises and falls like waves in water.

(2.) **An upward motion,** somewhat similar to that which follows an explosion of powder below the surface. This has been known to occur with sufficient force to throw heavy bodies considerable distances up into the air.

(3.) **A rotary motion,** which, from its destructive effects, is fortunately of rare occurrence.

Humboldt mentions an earthquake that happened in Chili where the ground was so shifted that three great palm trees were twisted around one another like willow wands.

There are two kinds of movement transmitted through the crust during earthquakes: these are the *earthquake motion proper, and the motion that produces the accompanying sounds.*

53. The Velocity of Earthquake Motion varies according to the *intensity* of the *shock* and the nature of the material through which it is transmitted. No average result can therefore be given. Various observers have estimated it at from 8 to 30 miles per minute.

54. The Sounds Accompanying Earthquakes vary both in kind and intensity. Sometimes they resemble the hissing noises heard when red-hot coals are thrown into water; sometimes they are rumbling, but more frequently they are of greater intensity, and are then comparable to discharges of artillery or peals of thunder.

The confused roaring and rattling are probably caused by the different rates of transmission of the sound through the air and rocks.

55. Duration of the Shocks.—When the area of disturbance is large, shocks of varying intensity generally follow each other at irregular intervals. Though, in general, the violence of the shock is soon passed, disturbances may occur at intervals of days, weeks, or even years.

During the earthquake in Calabria in 1783, when nearly 100,000 persons perished, the destructive vibrations lasted scarcely two minutes, but the tremblings of the crust continued long afterward. During the earthquake at Lisbon in 1755, when about the same number perished, the shock which caused the greatest damage continued but five or six seconds, while a series of terrible movements followed one another at intervals during the space of five minutes.

56. Cause of Earthquakes.—It is generally believed that the principal cause of earthquakes is *the force produced by the contraction of a cooling crust.*

During the cooling of the earth the crust continually *contracts,* and the pressure so produced, slowly accumulating for years, at last rends it in vast fissures, thus producing those violent movements of its crust called earthquakes. If this theory be admitted—and it is a probable one—the earth's crust must every now and then be in such a strained condition that the slightest increase of force from within, or of diminished resistance from without, would disturb the conditions of equilibrium, and thus result in an earthquake.

57. Strain Caused by Contraction consequent on cooling is well exhibited in the so-called "Prince Rupert's Drops," which are made by allowing melted glass to fall in drops through cold water. The sudden cooling of the outside produces powerful forces, which tend to compress the drop; but, since these forces balance one another, no movement occurs until, by breaking off the long end of the drop, one set of forces is removed, when the others, no longer neutralized, tear the drop into almost countless pieces.

Similar effects are produced by unequal contraction and expansion. Hot water poured into a tumbler will often crack it. The crackling sound of a stovepipe when suddenly heated or cooled is a similar effect.

58. Other Causes of Earthquakes.—Earthquakes may also be occasioned by—

(1.) **The sudden evolution of gases or vapors** from the pasty interior.

This is probably the cause of many of the slight shocks that occur in the neighborhood of active volcanic regions.

(2.) **Shocks caused by falling masses.**

Those who deny the existence of a pasty interior, endeavor to explain the production of earthquakes by the shock caused by the occasional caving in of huge masses of rocks, in caverns hollowed out by the action of subterranean waters; or by the gradual settling of the upturned strata in mountainous districts. There can be no doubt that even moderately severe shocks are caused by falling masses; but such a force is utterly inadequate to produce a shock like that which destroyed Lisbon, when an area of nearly 7,500,000 square miles was shaken.

59. Periodicity of Earthquakes.—It was formerly believed that earthquakes occurred without any regularity, but by a comparison of the times of occurrence of a great number it has been discovered that they occur more frequently—

(1.) In winter than in summer;

(2.) At night than during the day;

(3.) During the new and full moon, when the attractive force of the sun and moon acts simultaneously on the same parts of the earth.

Earthquake shocks are more frequent in winter, and during the night, because the cooling, and consequent contraction, occur more rapidly at these times, and therefore the gradually accumulating force is more apt to acquire sufficient intensity to rend the solid crust.

Earthquakes are more frequent during new and full moon, because the increased force on the earth's crust caused by the position of the sun and moon at these times, is then added to the accumulated force produced by cooling.

It has been asserted that in the equatorial regions earthquakes are especially frequent during the setting in of periodical winds called the monsoons, at the change of the rainy season or during the prevalence of hurricanes. These facts, however, are not well established.

60. Distribution of Earthquakes.—Earthquakes may occur *in any part of the world,* but are most frequent in volcanic districts. They are more frequent in mountainous than in flat countries. They are especially frequent in the highest mountains. According to Huxley, fairly pronounced earthquake shocks occur in some part of the earth at least three times a week.

There is, in many instances, an undoubted connection between volcanic eruptions and earthquakes. Humboldt relates that during the earthquake at Riobamba, when some 40,000 persons perished, the volcano of Pasto ceased to emit its vapor at the exact time the earthquake began. The same is related of Vesuvius at the time of the earthquake at Lisbon.

61. Phenomena of Earthquakes.—In order to give some idea of the phenomena by which severe earthquake shocks are attended, we append a brief description of the earthquake which destroyed the city of Lisbon, on the 1st of November, 1755. The loss of life on this occasion was the more severe, since the shock occurred on a holy day, when nearly the whole population was assembled in the churches. A sound like thunder was heard, and, almost immediately afterward, a series of violent shocks threw down nearly every building in the city. Many who escaped the falling buildings perished in the fires that soon kindled, or were murdered by lawless bands that afterward pillaged the city.

The ground rose and fell like the waves of the sea; huge chasms were opened, into which many of the buildings were precipitated. In the ocean a huge wave, over 50 feet high, was formed, which, retreating for a moment, left the bar dry, and then rushed toward the land with frightful force. This was repeated several times, and thousands perished from this cause alone. The neighboring mountains, though quite large, were shaken like reeds, and were rent and split in a wonderful manner.

This earthquake was especially remarkable for the immense area over which the shock extended. It reached as far north as Sweden. Solid mountain-ranges—as, for example, the Pyrenees and the Alps—were severely shaken. A deep fissure was opened in France. On the south, the earthquake waves crossed the Mediterranean and destroyed a number of villages in the Barbary States. On the west, the waves traversed the bed of the Atlantic, and caused unusually high tides in the West Indies. In North America the movements were felt as far west as the Great Lakes. Feebler oscillations of the ground occurred at intervals for several weeks after the main shock.

62. Non-volcanic Igneous Eruptions.—In regions remote from volcanoes, melted rock has been forced up from the interior through fissures in the rocks of nearly all geological formations. On cooling, the mass forms what is called a *dyke.* Dykes vary in width from a few inches to several yards. They are generally much harder than the rocks through which they were forced, and, being less subject to erosion, often project considerably above the general surface.

From their mode of formation, dykes are generally without traces of stratification, but by cooling a series of transverse fractures are sometimes produced. The dykes thus obtain the appearance of a series of columns, called *basaltic columns.*

Igneous rocks of this description are found in all parts of the continents, but are especially common near the borders of mountainous districts. Fingal's Cave, in Scotland, is a noted example of basaltic columns.

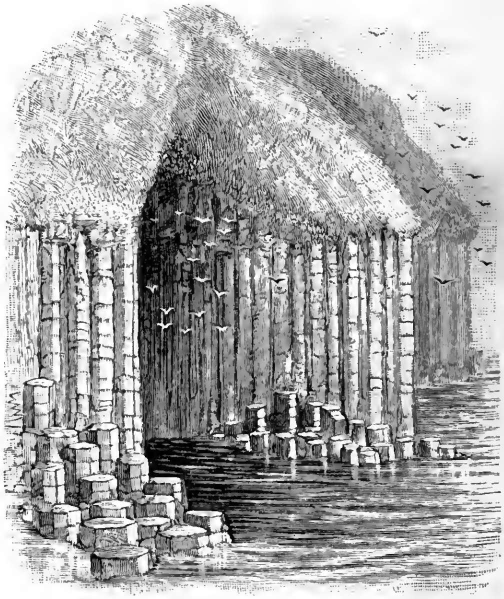


Fig. 24. Basaltic Columns, Fingal's Cave, Scotland.

63. Gradual Elevations and Subsidences.—Besides the sudden changes of level produced by earthquakes, there are others that take place *slowly, but continuously,* by which large portions of the surface are *raised* or *lowered* from their former positions. The rate of movement is very slow—probably never exceeding a few feet in a century. The following examples are the most noted:

The *Scandinavian peninsula* (Norway and Sweden) is slowly *rising in the north* and *sinking in the south.*

The southern part of the *coast of Greenland* is *sinking.*

The North American coast, from Labrador to New Jersey, is *rising.*

The Andes Mountains, especially near Chili, are gradually *rising.*

The Pacific Ocean, near the centre, is *sinking* over an area of more than 6000 miles.

The cause of these movements is to be traced to the warping action caused by *gradual contraction of a cooling crust.*

SYLLABUS.

The earth was originally melted throughout. It afterward cooled on the surface and formed a crust. The earth's original fluidity is rendered probable—

(1.) By the spherical shape of the earth;

(2.) By the crystalline rocks underlying all others; and

(3.) By the greater heat of the earth during geological time.

The interior is still in a highly-heated condition. This is proved—1st. By the increased heat of the crust as we go below the surface; 2d. By the escape of lava from volcanoes in all latitudes.

The following opinions are held concerning the condition of the interior of the earth:

(1.) That the earth has a solid centre and crust, with a heated layer between.

(2.) That the earth has a solid crust only, and an interior sufficiently heated to be in a fused or in a pasty condition.

(3.) That the earth is solid throughout, but highly heated in the interior.

The thickness of the crust is not known. It is probable that the portions solidified by cooling pass insensibly into those that are nearly solid from the combined influence of loss of heat and increasing pressure. The heated interior, however, must lie comparatively near the surface.

The effects produced by the heated interior on the crust are—1st. Volcanoes; 2d. Earthquakes; 3d. Non-volcanic igneous eruptions; and 4th. Gradual elevations or subsidences.

Volcanic mountains are of a variety of shapes. Near their craters the cone shape predominates, and serves to distinguish these mountains as a class.

The ejected materials of volcanoes are—1st. Melted rock or lava; 2d. Ashes or cinders; 3d. Vapors or gases.

These materials are brought up from great depths into the volcanic mountain by the force produced by a contracting globe. They may escape from the crater—1st. By the pressure of highly-heated vapors; or, 2d. By the pressure of a column of melted lava.

The inclination of the slopes of the volcanic cone depends on the materials of which it is composed. Ash-cones are steeper than those formed of lava.

Eruptions are of two kinds, explosive and non-explosive.

High volcanic mountains are, as a rule, characterized by non-explosive eruptions.

Volcanoes occur both on the surface of the land and on the bed of the ocean.

Those on the land occur mainly near the borders of sinking oceans, where the crust is weakest.

The principal volcanic districts of the world are—1. Along the shores of the Pacific; 2. On the islands which are scattered over the Pacific; 3. Scattered over the seas which divide the northern and southern continents; 4. In the northern and central parts of the Atlantic Ocean; 5. In the western and central parts of the Indian Ocean.

The centres of volcanic activity are found in the Antilles and in the Sunda Islands, where several lines of fracture cross each other.

Subordinate volcanic phenomena are seen in—1. Mud volcanoes; 2. Solfataras; 3. Geysers.

Earthquakes are shakings of the earth's crust; they may occur with or without a permanent displacement.

The following facts have been discovered as to earthquakes:

(1.) Their place of origin is not very deep-seated.

(2.) The area of disturbance increases with the energy of the shock and the depth of the origin.

(3.) The shape of the origin is that of a line, and not that of a point.

(4.) The shape of the area of disturbance depends on the elasticity of the materials through which the shock moves.

(5.) The earthquake motion travels through the earth as spherical waves which move outward in all directions from the origin of the disturbance.

The movement at the earth's surface may be—1st. In the form of a gentle wave; 2d. An upward motion; 3d. A rotary motion.

The velocity with which the earthquake motion is transmitted varies with the intensity of the shock and the nature of the materials through which it is propagated.

There are two distinct kinds of motion accompanying earthquake waves: the earthquake motion proper, and the motion producing the accompanying sounds.

As a rule, the earthquake shocks which produce the greatest damage are of but short duration, generally but a few seconds or minutes. Slighter disturbances may follow the main shock at intervals of days, weeks, or even years.

Earthquake shocks are more frequent—1st. In winter than in summer; 2d. At night than during the day; 3d. During the time of new and full moon than at any other phase.

Earthquakes are mainly caused by the gradually increasing force produced by the contraction of the crust.

Earthquakes are also to be attributed to the forces which eject the molten matter from the craters of volcanoes.

Slight earthquake shocks may be occasioned by the falling in of masses of rock from the roofs of subterranean caverns, or by the settling of upturned strata.

Earthquakes may occur in any part of the earth, but are most frequent in volcanic and in mountainous regions.

Dykes are masses of rock formed by the gradual cooling of melted matter which has been forced up through fissures from the interior.

Basaltic columns are formed by dykes. They owe their columnar structure to fractures produced on cooling.

The crust of the earth is subject to gradual as well as to sudden changes of level.

The Scandinavian peninsula is rising on the north and sinking on the south.

The southern coast of Geeenland is sinking.

The North American coast, from Labrador to New Jersey, is rising.

The range of the Andes near Chili is rising.

The bed of the Pacific in the neighborhood of the Polynesian island chain is sinking.

These movements are caused by the contraction of a cooling crust.

REVIEW QUESTIONS.

The Heated Interior.

Enumerate the proofs that the interior of the earth is still in a highly-heated condition.

Name some circumstances which render it probable that the earth was originally melted throughout.

What is the average rate of increase of temperature with descent below the surface?

How can it be shown that the whole interior of the earth is filled with highly-heated matter?

Why is it so difficult to assign a definite limit to the thickness of the earth's crust?

Is the interior of the earth supposed to be in as fluid a condition as that of the lava which escapes from a volcano?

What four classes of effects are produced in the crust by the heated interior?

Volcanoes.

What are volcanoes? What connection have they with the interior of the earth? How do active volcanoes differ from those which are extinct?

Explain the origin of the conical form of volcanic mountains.

Which generally produces the more destructive effects, ashes or lava? Why?

Enumerate the materials which are ejected from the interior of the earth through the craters of volcanoes.

What is tufa? How is it formed?

Which has the greater inclination, a lava-cone or an ash-cone?

Explain in full the manner in which the shrinkage, or contraction of the earth on cooling, produces a pressure both in the interior and in the crust.

By what forces are volcanic eruptions produced?

Into what two classes may all volcanic eruptions be divided? How are those of each class caused?

Give an example of each of these classes.

What is the highest volcano in the world?

Under what five regions may all the volcanoes in the world be arranged?

In what parts of the world are volcanoes most numerous?

Why are volcanoes more numerous here than elsewhere?

Name some of the regions of submarine volcanoes.

Why are all volcanoes found near the coasts of the continents or on islands?

What are mud volcanoes? Solfataras?

Earthquakes.

What are earthquakes? Into what two classes may they be divided?

Name some facts that have been discovered about earthquakes.

Name three kinds of earthquake motion. Which is the most dangerous?

Describe the sounds which accompany earthquakes.

What is the main cause of earthquakes? To what other causes may they be attributed?

What facts have been discovered respecting the periodicity of earthquakes?

Give a short description of the earthquake which destroyed the city of Lisbon.

Are any portions of the earth free from earthquake shocks?

In what parts of the earth are earthquake shocks most frequent?

What are dykes? How were they formed?

Enumerate some of the gradual changes of level which are now occurring in the crust of the earth. By what are these changes caused?

MAP QUESTIONS.

Trace on the map the five principal volcanic districts of the earth.

Which contains the greater number of volcanoes, the Atlantic or the Pacific shores of the continents?

Does the eastern or the western border of the Indian Ocean contain the greater number of volcanoes?

Name the principal volcanic islands of the Atlantic. Of the Indian. Of the Pacific.

Locate the following volcanoes: Hecla, Pico, Kilauea, Sarmiento, Llullayacu, Egmont, Cosiguina, Teneriffe, Antisana, Kilimandjaro, Demavend, Peshan, Osorno, Erebus, and Terror.

Name the principal volcanic mountains of North America.

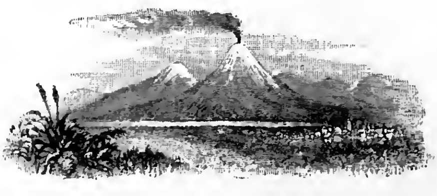
In what part of the Atlantic Ocean are submarine eruptions especially frequent?

Name three noted volcanoes of the Mediterranean Sea.

Name the portions of the earth which were shaken by the earthquake of Lisbon. When did this earthquake occur?

What noted volcanoes are found in the region visited by the earthquake of Lisbon?

In what portions of the Eastern Hemisphere are earthquake shocks especially frequent? In what portions of the Western Hemisphere?



SECTION II.

THE OUTSIDE OF THE EARTH.

CHAPTER I.

The Crust of the Earth.

64. Composition of the Crust.—The elementary substances are not equally distributed throughout the earth's crust. Many of these substances occur only in extremely small quantities, while others are found nearly everywhere.

Although the deepest cutting through the earth's crust does not extend vertically more than about two miles below the level of the sea, yet the upturning of the strata, or the outcropping of the different formations, enables us to study a depth of about sixteen miles of the earth's crust.

A careful study of the composition of this part of the crust shows that *oxygen* constitutes nearly one-half of it, by weight. *Silicon*, an element which, when combined with oxygen, forms silica or quartz, constitutes, either as sand, or combined with various bases as silicates, one-fourth; so that these two elements form at least *three-fourths, by weight*, of the entire crust. The following are also prominent ingredients of rocks—*aluminium*, which, when combined with oxygen, forms alumina, the basis of clay; *magnesium, calcium, potassium, sodium, iron*, and *carbon*. These *nine* substances, according to Dana, form $\frac{977}{1000}$ths, by weight, of the entire crust.

Sulphur, hydrogen, chlorine, and *nitrogen* also occur frequently. The remaining elements are of comparatively rare occurrence.

65. The Origin of Rocks.—When the earth was yet a melted globe, the water which now covers the larger portion of its surface hung over it, uncondensed, either as huge clouds or as masses of vapor. After a comparatively thin crust had formed, the vapor was condensed as rain, and covered the earth with a deep layer of boiling water. Occasionally the cooling crust was broken by the increasing tension, and portions of the molten interior were forced out and spread over the surface. The muddy waters then cleared by depositing layers of sediment over the ocean's bed.

When, by long-continued cooling, the crust became thicker, the breaking out of the interior occurred less frequently, and contraction, wrinkling the surface in huge folds, caused portions to emerge from the ocean and form dry land. During all this time the waters were arranging the looser materials in layers or *strata* which were originally more or less horizontal; but wherever the contraction forced the melted interior through the crust or upturned it in huge folds, the horizontal position of the deposits was destroyed; and even when not so disturbed, the heat of the interior, escaping through fissures, often produced such alterations as to confuse or completely to obliterate all traces of their regular bedding.

The almost inconceivable extent of geological time may be inferred from the calculations of Helmholtz, based on the rapidity of the cooling of lava. These calculations show that in passing from a temperature of 2000° C. to 200° C. a time equal to *three hundred and fifty million years* must have elapsed. Before this a still greater time must have elapsed, and after it came the exceedingly great extent of geological time proper.

66. According to their Origin, rocks may be divided into three distinct classes:

(1.) **Igneous Rocks**, or those ejected in a melted condition from the interior, and afterward cooled.

(2.) **Aqueous Rocks**, or those deposited as sediment by water. When mineral matter settles in water, the coarser, heavier particles reach the bottom first, so that a sorting action occurs, which makes the different layers or strata vary in the size and density of their particles, and, to a great extent, in their composition.

Aqueous rocks are sometimes called *sedimentary* rocks.

(3.) **Metamorphic Rocks**, or those originally deposited in layers, but afterward so changed by the action of heat as to lose all traces of stratification.

This change, which is called *metamorphism, is caused by heat acting under pressure in the presence of moisture.* Under these conditions a far less intense heat is required to remove all traces of stratification. Metamorphism appears to consist mainly in a rearrangement of the chemical constituents of the rocks.

67. According to their Condition, rocks may be divided into two classes:

(1.) **Stratified Rocks**, or those arranged in regular layers. Aqueous rocks are always stratified, and sometimes, though rarely, metamorphic rocks are stratified.

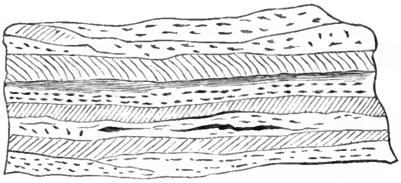


Fig. 25. Stratified Rock.

In Fig. 25 the different layers or strata are shown by the shadings. Stratified rocks are the most common form of rocks found near the earth's surface.

Stratified rocks are largely composed of fragments of older rocks; for this reason they are sometimes called *fragmental* rocks.

(2.) **Unstratified Rocks**, or those destitute of any arrangement in layers. They are of two kinds:

(1.) *Igneous*, or those which were never stratified.

(2.) *Metamorphic*, or those which were once stratified, but have lost their stratification by the action of heat.

Unstratified rocks are sometimes called *crystalline* rocks, because they consist of crystalline particles.

68. Fossils are the remains of animals or plants which have been buried in the earth by natural causes. Generally, the soft parts of the organism have disappeared, leaving only the harder parts. Sometimes the soft parts have been gradually removed, and replaced by mineral matter, generally lime or silica; thus producing what are called *petrifactions*. At times the mere impression of the animal or plant is all that remains to tell of its former existence.

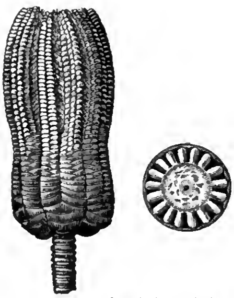


Fig. 26. Fossil Encrinite.

When the remains of an animal or plant are exposed to the air or buried in dry earth, they generally decompose and pass off almost entirely as gases; but when buried under water or in damp earth, their preservation is more probable. Therefore, the species most likely to become fossilized are those living in water or marshes, or in the neighborhood of water or marshes.

69. According to the Presence or Absence of Fossil Remains, rocks may be divided into two classes:

(1.) **Fossiliferous Rocks**, or those which contain fossils. They are stratified and are of aqueous origin. Metamorphic rocks, in very rare instances, are found to contain fragments of fossils.

(2.) **Non-fossiliferous Rocks**, or those destitute of fossils. They include all igneous rocks and most of those that are metamorphic.

70. Palæontology is the science which treats of fossils. Palæontology enables us to ascertain the earth's condition in pre-historic times, since by a careful examination of the fossils found in any rocks we discover what animals and plants lived on the earth while such rocks were being deposited. The earth's strata thus become the pages of a huge book; and the fossils found in them, the writings concerning the old life of the world. By their careful study geologists have been enabled to find out much of the earth's past history.

71. Division of Geological Time.—A comparison of the various species of fossils found in the earth's crust discloses the following facts:

(1.) The fossils found in the lowest rocks bear but a slight resemblance to the animals and plants now living on the earth.

(2.) The fossils found in the intermediate strata bear a resemblance to existing species, though this resemblance is not so strongly marked as in the upper strata.

(3.) The fossils found in the upper strata bear a decided resemblance to existing species.

It is on such a basis that the immense extent of geological time is divided into the following shorter periods or times:

(1.) **Archæan Time**, or the time which witnessed the dawn of life. This time included an extremely long era, during most of which the conditions of temperature were such that no life could possibly have existed. Toward its close, however, the simplest forms of life were created.

The lower Archæan rocks resulted from the original cooling of the molten earth, and cover its entire surface, including the floor of the ocean. On these rest less ancient Archæan rocks, formed as sedimentary deposits of the older rocks.

The rocks of the Archæan Time in North America include the Laurentian, the lowest, named from the river St. Lawrence, near which they occur, and the Huronian, named from their occurrence near Lake Huron.

(2.) **Palæozoic Time**, or ancient life, included the time during which the animals and plants bore but little resemblance to those now living.

(3.) **Mesozoic Time**, or middle life, included the time during which the animals and plants began to resemble those now living.

(4.) **Cenozoic Time,** or recent life, included the time during which the animals and plants bore decided resemblance to those now living.

These *times* are divided into *ages.*

Archæan Time includes—

(1.) The Azoic Age;

(2.) The Eozoic Age.

Palæozoic Time, or, as it is sometimes called, the Primary, includes—

(1.) The Age of Invertebrates, or the Silurian;

(2.) The Age of Fishes, or the Devonian;

(3.) The Age of Coal-plants, or the Carboniferous.

Mesozoic Time, or, as it is sometimes called, the Secondary, includes the Age of Reptiles.

Cenozoic Time includes—

(1.) The Tertiary, or the Age of Mammals;

(2.) The Quaternary, or the Age of Man.

Where no disturbing causes existed, and the land remained under the seas, the rocks deposited during these periods were thrown down in regular strata, one over the other. The Archæan were the lowest; above them were the Palæozoic, then the Mesozoic, and finally those of the Cenozoic. Generally, however, frequent dislocations of the strata have disturbed the regular order of arrangement.

72. The Azoic Age included all the time from the first formation of the crust to the appearance of animal and vegetable life.

The Eozoic Age is that which witnessed the dawn of life. The sedimentary rocks of this age are so highly metamorphosed that nearly all traces of life have been obliterated. Among plants, the marine *algæ,* or sea-weeds, and among animals, the lowest forms of the *protozoa,* were probably the chief species.

73. The Age of Invertebrates, or the Silurian, is sometimes called the Age of Mollusks. Among plants, *algæ,* or sea-weeds, are found; among animals, *protozoa, radiates, articulates,* and *mollusks,* but no *vertebrates.* Hence the name, Age of Invertebrates. Mollusks were especially numerous.

The name *Silurian* is derived from the ancient Silures, a tribe formerly inhabiting those parts of England and Wales where the rocks abound.

74. The Age of Fishes, or the Devonian.—During this age all the sub-kingdoms of animals are found, but the *vertebrates* first appear, being represented by *fishes,* and from this fact the name has been given to the age. *Land-plants* are also found. Immense beds of limestone and red sandstone were deposited.

The name *Devonian* is derived from the district of Devonshire, England, where the rocks abound.

75. The Age of Coal-Plants, or the Carboniferous.—The continents during this age consisted mainly of large, flat, marshy areas, covered with luxuriant vegetation, subject, at long intervals, to extensive inundations. The decaying vegetation, decomposing under water, retained most of its solid constituent, carbon, and formed beds of coal. All the sub-kingdoms of animals were represented and reptiles also existed. The comparatively few land-plants of the preceding age now increased and formed a dense vegetation.

To favor such a luxuriant vegetation the air must have been warm and moist. Since all the coal then deposited previously existed in the air as carbonic acid, the Carboniferous Age was necessarily characterized by a purification of the atmosphere.

Fig. 27. Carboniferous Landscape. (A restoration.)

Formation of Coal.—In every 100 parts of dry vegetable matter there are about 49 parts of carbon, 6 of hydrogen, and 45 of oxygen. The carbon is a solid; the hydrogen and oxygen are gases. It is from the carbon that coal is mainly formed. When the decomposition of the vegetable matter takes place in air, the carbon passes off with the hydrogen and oxygen as various gaseous compounds; but when covered by water, most of the carbon is retained, together with part of the oxygen and hydrogen. Although every year our forests drop tons of leaves, no coal results, the deposit of one year being almost entirely removed before that of the next occurs.

It has been computed that it would require a depth of eight feet of compact vegetable matter to form one foot of bituminous coal, and twelve feet of vegetable matter to form one foot of anthracite coal. Anthracite coal differs from bituminous mainly in the greater metamorphism to which it has been subjected; it contains a greater proportion of carbon and less hydrogen and oxygen.

76. The Age of Reptiles.—In this age the animals and plants begin to resemble existing species. The age is characterized mainly by the preponderance of reptiles, many of which were very large, as, for example, the *plesiosaurus*, an animal with a long, snake-like neck and a huge body, or the *ichthyosaurus*, with a head like a crocodile and short neck and large body. Both of these animals were furnished with fin-like paddles, and lived in the water. Huge *pterodactyls*, or bat-like saurians, flew in the air or paddled in the water. Mammals and birds also occur.

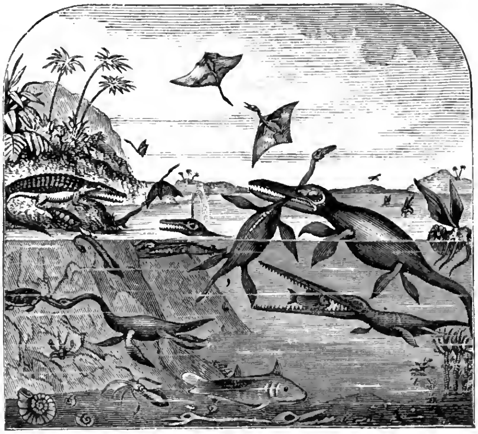


Fig. 28. The Age of Reptiles. (A restoration.)

77. The Age of Mammals, or the Tertiary Age.—Mammals, or animals that suckle their young, occurred in great numbers, and, being the highest

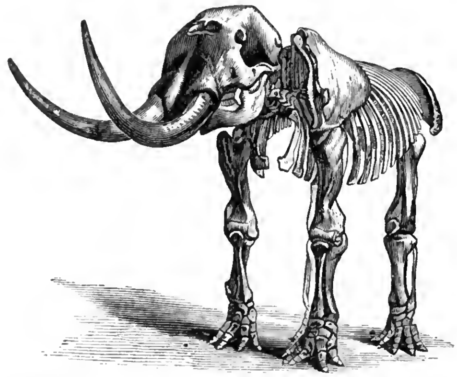


Fig. 29. Mastodon giganteus. An Animal of the Mammalian Age

type of life, gave the name to the age. The animals and plants of the Mammalian Age closely resembled existing species, though most of them were much larger; as, for example, the *dinotherium*, a huge animal, with a trunk like an elephant, but with downward-turned tusks; the *palæotherium*, and many others.

78. The Era of Man, or the Quaternary Age, witnessed the introduction of the present animals and plants and the creation of man.

79. Changes Now Occurring in the Earth's Crust.—*Geological time* was characterized by extensive changes, both in the *kind and luxuriance of life, and in the nature of its distribution.*

The earth is still undergoing extensive changes, which are caused by the following agencies:

(1.) **By the Winds,** which often carry sand from a desert and distribute it over fertile plains: in this manner the narrow tract of fertile land on the borders of the Nile, in Egypt, receives much sand from the Sahara. The winds are also piling up huge mounds of sand along the sea-coasts, forming what are called *dunes*, or *sandhills.*

(2.) **By the Moisture of the Atmosphere,** soaking into porous rocks or running into the crevices between solid ones. This water in freezing expands with force sufficient to rend the rock into fragments, which are carried away by the rivers or, when sufficiently small, by the winds.

(3.) **By the Action of Running Water.**—Rivers wash away portions of their banks or cut their

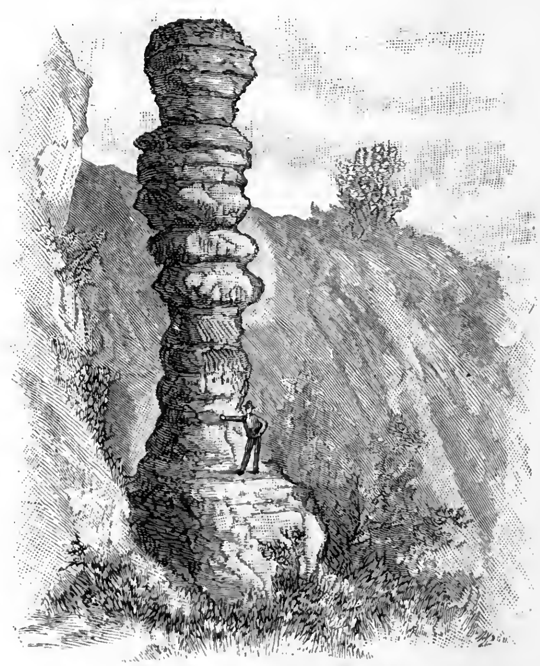


Fig. 30. Curious Effect of Erosion.

way through their channels. This action is called *erosion.* It occurs even in the hardest rocks. The materials thus carried away are spread over the lowlands near the mouth of the river or thrown into the sea, where they often form large deposits. By the constant action of these causes the *mean heights of the continents are decreasing and their breadths increasing.*

The most remarkable instance of erosion is found in the cañons of the Colorado River, where the waters have eaten a channel through the hard limestones and granites that form the bed of the stream, until they now run through gorges whose walls ascend almost perpendicularly to the height of from 3000 to 6000 feet.

A good idea of this great depth may be obtained by walking along a straight street for about a mile (5280 feet), and then imagining the street set upright in the air. On looking down toward the starting-place, we would see it as it would appear at the bottom of a hole about 6000 feet deep.

The forms produced by erosion are often extremely fantastic. Tall, slender, needle-like columns, capped by a layer of harder rock, sometimes occur, thus showing in a marked manner an effect of erosion.

(4.) **By the Action of Ocean Waves,** changing the outlines of coasts; as may be seen in portions of the coasts of England and Scotland.

(5.) **By the Agency of Man,** witnessed mainly in the destruction of the forests over extended areas.

(6.) **By the Contraction of a Cooling Crust,** resulting in—1. Earthquakes; 2. Volcanoes; 3. Gradual uplifts and subsidences.

CHAPTER II.

Distribution of the Land-Areas.

80. Geographic Effects of Light, Heat, and Moisture.—The peculiarities observed in the distribution of animal and vegetable life are caused by differences in the distribution of *light, heat,* and *moisture.* Since light, heat, and moisture are influenced by the interaction of *land, water,* and *air,* we must first study the distribution and grouping of these *inorganic* or *dead forms* before we can understand those that are *living.*

81. The Distribution of the Land.—Of the 197,000,000 square miles that make up the earth's surface, about 144,000,000 are water and 53,000,000 land. The proportion is about as the square of 5 is to the square of 3. If, therefore, we erect a square on a side of five, its entire area will represent the relative water-area of the globe; while a square whose side is three will represent the relative land-area.

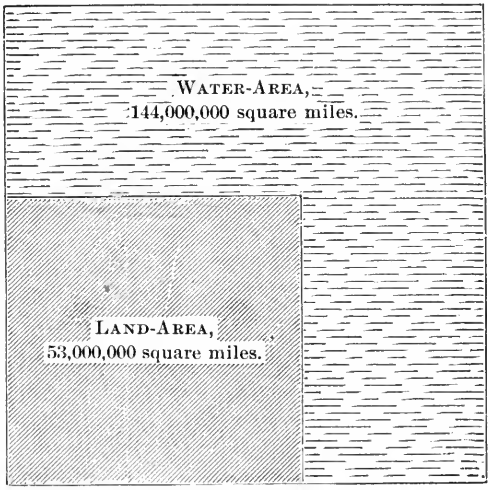


Fig. 31. Relative Land- and Water-Areas.

82. The Distribution of the Land can be best studied when arranged under two heads:

(1.) **The Horizontal Forms of the Land,** or the different shapes produced in the land-areas by the coast lines, or by the contact of land and water;

(2.) **The Vertical Forms of the Land,** produced by the irregularity of the surface of the high lands and low lands.

83. The Horizontal Forms.—The land-areas are divided into *continents* and *islands.*

The Eastern Hemisphere contains four continents: Europe, Asia, Africa, and Australia. The first three form one single mass, which is called *the Eastern Continent.*

Though the word "continent" strictly refers to an extended area of land entirely surrounded by water, usage has sanctioned the application of the term to the grand divisions of the land. It is quite correct, therefore, to speak of the North American Continent, the Asiatic Continent, etc.

The Western Hemisphere contains two continents: North and South America; these constitute what is called *the Western Continent.*

The following are the extremities of the continents:

In the Eastern Continent—
Most northern point, Cape Chelyuskin, lat. 78° 16′ N.
Most southern point, Cape Agulhas, lat. 34° 51′ S.
Most eastern point, East Cape, long. 170° W.
Most western point, Cape Verd, long. 17° 34′ W.

In the Western Continent—
Most northern point, Point Barrow, lat. 72° N.
Most southern point, Cape Froward, lat. 53° 53′ S.
Most western point, Cape Prince of Wales, long. 168° W.
Most eastern point, Cape St. Roque, long. 35° W.

84. Peculiarities in the Distribution of the Land:

(1.) *The continents extend farther to the north than to the south.*

(2.) *The land masses are crowded together near the north pole,* which they surround in the shape of an irregular ring.

(3.) *The three main southern projections of the land*—South America, Africa, and Australia—are separated from each other by extensive oceans.

85. Land and Water Hemispheres.—The accumulation of the land in the north and its separation in the south lead to a curious result—*nearly all the land is collected in one hemisphere.*

If one point of a pair of compasses be placed at the north pole of a globe, and the other stretched out to reach to any point on the equator, they will describe on the surface of the globe a great circle, and consequently will divide the globe into hemispheres. If, while they are stretched this distance apart, one of the points be placed at about the city of London, a circle swept with the other point will divide the earth into land and water hemispheres. Such a great circle would pass through the Malay Peninsula and the coast of Peru.

The Land Hemisphere contains all of North America, Europe, and Africa, and the greater part of South America and Asia. The Water Hemisphere contains the southern portions of South America, the Malay Peninsula, and Australia.

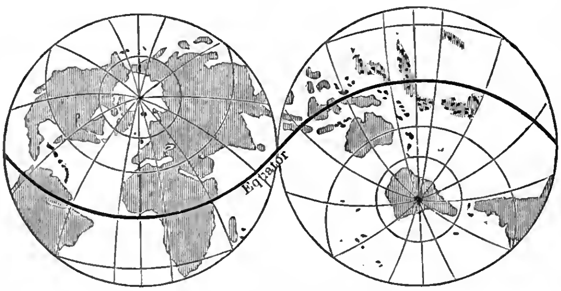


Fig. 32. Land and Water Hemispheres.

86. Double Continents.—The six grand divisions or continents may be divided into three pairs, called Double or Twin Continents.

Each Double Continent consists of a northern and southern continent, almost separated from each other, but connected by a narrow isthmus or island chain.

The three double continents are North and South America, Europe and Africa, and Asia and Australia. There are, therefore, three northern and three southern continents.

The northern continents lie almost entirely in temperate latitudes, while the southern lie mainly in the tropics.

87. Lines of Trend.—The study of any map of the world on a Mercator's projection will disclose the following peculiarities in the earth's structure:

There are two great systems of courses, trends, or lines of direction, along which the shores of the continents, the mountain-ranges, the oceanic basins, and the island chains extend.

These trends extend in a general north-easterly and north-westerly direction, and intersect each other nearly at right angles.

North-east Trends.—A straight ruler can be so placed along the south-eastern coasts of Greenland and the south-eastern coasts of North America that its edge will touch most of their shore lines. Its general direction will be *north-east.*

It can be similarly placed along the south-eastern coast of South America, the north-western coast of Africa, and most of the western coast of Europe; along the south-eastern coasts of Africa; the south-eastern coast of Hindostan; and along the eastern coast of Asia, without its general direction differing much from *north-east.*

North-west Trends.—A straight ruler can be so placed as to touch most of the western shores of North America and part of the western coast of South America; most of the western coasts of Greenland, or the north-eastern coasts of North America, and part of the western coasts of Africa. All these courses are sensibly *north-west.*

If placed with one end at the mouth of the Mackenzie River, and the other on the south-western extremity of Lake Michigan, it will cut nearly all the great lakes in Central British America. The direction of the island chains of the Pacific Ocean in particular is characterized by these two trends, many of the separate islands being elongated in the direction of the trend of their chain.

88. Continental Contrasts. — *The main prolongation of the western continent extends in the line of the north-western trend, while that of the eastern continent extends in the line of the north-eastern trend.* The axes of the continents, or their lines of general direction, therefore, intersect each other nearly at right angles.

The western continent extends far north and south of the equator, while the eastern lies mainly north of the equator. *The Western Continent, therefore, is characterized by a diversity of climates; the Eastern Continent, by a similarity.* The distribution of vegetable and animal life in each continent is necessarily affected by the peculiarities of its climate.

It is from the prevalence of the lines of trend that the general shape of the continents is mainly triangular. An excellent system of map-drawing has been devised on this peculiarity.

The following peculiarities exist in the coast lines of the continents:

The coast lines of the northern continents are very irregular, the shores being deeply indented with gulfs and bays, while those of the southern continents are comparatively simple and unbroken.

The continents are most deeply indented near the regions where the pairs of northern and southern continents are nearly separated from each other. *These regions correspond with the lines of great volcanic activity, and appear to be areas over which considerable subsidence has occurred.*

The continents differ greatly from one another in their indentations. Europe is the most indented of all the continents. The area of her peninsulas, compared with that of her entire area, is as 1 to 4. Asia comes next in this respect, the proportion being 1 to 5½, while in North America it is but 1 to 14.

The following Table gives in the first column the area of each of the continents, in the second the length of coast line, and in the third the number of square miles of area to one mile of coast line:

CONTINENTS.	AREA.	COAST LINE.	Sq. m. of surface for 1. m. of coast.
Asia	17,500,000 sq. miles.	35,000 miles.	500
Africa	12,000,000 "	16,000 "	750
North America	8,400,000 "	22,800 "	368
South America	6,500,000 "	14,500 "	449
Europe	3,700,000 "	19,500 "	190
Australia	3,000,000 "	10,000 "	300

Europe has, in proportion to its area,
About three times as much coast line as Asia.
About four times as much as Africa.
About twice as much as North America.
More than twice as much as South America.

Europe is the most, and Africa the least, deeply indented of the continents.

CHAPTER III.

Islands.

89. Relative Continental and Insular Areas.—Of the 53,000,000 square miles of land, nearly 3,000,000, or about *one-seventeenth*, is composed of islands.

90. Varieties of Islands.—Islands are either *continental* or *oceanic*.

Continental Islands are those that lie near the shores of the continents. They are continuations of the neighboring continental mountain-ranges or elevations, which they generally resemble in geological structure. *They may, therefore, be regarded as projections of submerged portions of the neighboring continents. Continental islands have, in general, the same lines of trend as the shores of the neighboring mainland.*

Continental islands, as a rule, are larger than oceanic islands. This is caused by the shallower water in which continental islands are generally situated. Papua and Borneo have each an area of about 250,000 square miles; either of these islands is more than twice as large as the combined areas of Great Britain and Ireland.

91. American Continental Island Chains.

(1.) **The Arctic Archipelago** comprises the large group of islands north of the Dominion of Canada. It consists of detached portions of the neighboring continent.

(2.) **The Islands in the Gulf of St. Lawrence** and its neighborhood are apparently the northern prolongations of the Appalachian mountain-system.

(3.) **The Bahamas** lie off the south-eastern coast of Florida, to whioh they belong by position and structure. Their general trend is north-west.

(4.) **The West Indies** form a curved range, which connects the peninsula of Yucatan with the coast-mountains of Venezuela. Here both trends appear, though the north-western predominates.

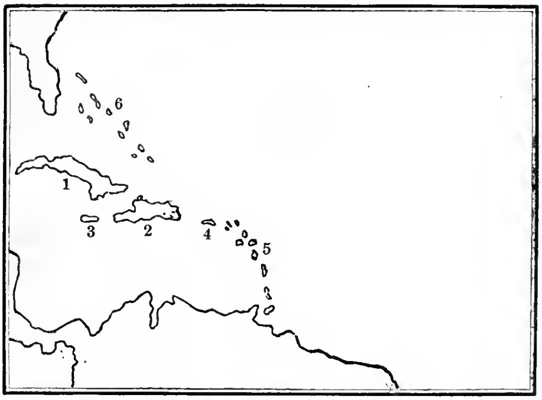


Fig. 33. West India Island Chain.

1, Cuba; 2, Hayti; 3, Jamaica; 4, Porto Rico; 5, Caribbee Islands; 6, Bahamas.

(5.) **The Aleutian Islands** form another curved range, which connects the Alaskan Peninsula with Kamtchatka; their general trend is north-east. They are connected with the elevations of the North American continent.

(6.) **The Islands west of the Dominion of Canada and Alaska.** These are clearly the summits of submerged northern prolongations of the Pacific coast ranges.

(7.) **The Islands of the Patagonian Archipelago** are the summits of submerged prolongations of the Andes of Chili.

92. Asiatic Continental Island Chains consist of a series of curved ranges extending along the entire coast, and intersecting each other nearly at right angles.

(1.) **The Kurile Islands** are a prolongation of the Kamtchatkan range.

(2.) **The Islands of Japan** extend in a curve from Saghalien to Corea.

(3.) **The Loo Choo Islands** extend in a curve from the islands of Japan to the island of Formosa.

(4.) **The Philippines** form two diverging chains, which merge on the south into the Australasian Island chain. The eastern chain extends to the southern extremity of Celebes, and the western to that of Borneo.

The Asiatic chains belong to a submerged mountain-range extending from Kamtchatka to the Sunda Islands. Their general direction is parallel to the elevations of the coast.

93. The Australasian Island Chain.

The Australasian Island chain is composed of a number of islands extending along curved trends over a length of nearly 6000 miles, from Sumatra to New Zealand. The islands extend along three curved lines, whose general direction is north-west.

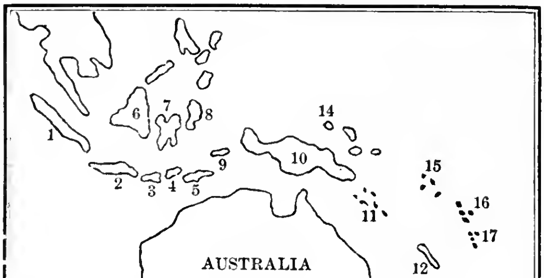


Fig. 34. Australasian Island Chain.

1, Sumatra; 2, Java; 3, Sumbawa; 4, Flores; 5, Timor; 6, Borneo; 7, Celebes; 8, Gilolo; 9, Ceram; 10, Papua; 11, Louisiade Archipelago; 12, New Caledonia; 13, New Zealand; 14, Admiralty Islands; 15, Solomon's Archipelago; 16, Santa Cruz; 17, New Hebrides.

The Australasian chain was probably connected with the Asiatic continent during recent geological time, and separated from it by subsidence. Its numerous volcanoes and coral formations prove that subsidence is still taking place.

94. Peculiarity of Distribution.—The following peculiarity is noticed in the distribution of continental islands:

Each of the continents has an island, or a group of islands, near its south-eastern extremity. For example, North America has the Bahamas and the West Indies; Greenland has Iceland; South America has the Falkland Islands; Africa has Madagascar; Asia has the East Indies; and Australia has Tasmania.

95. Oceanic Islands are those situated far away from the continents. They occur either in vast chains, which generally extend along one or the other of the two lines of trend, or as isolated groups.

Oceanic Island Chains.

The following are the most important:

(1.) The Polynesian Chain;
(2.) The Chain of the Sandwich Islands;
(3.) The Tongan or New Zealand Chain.

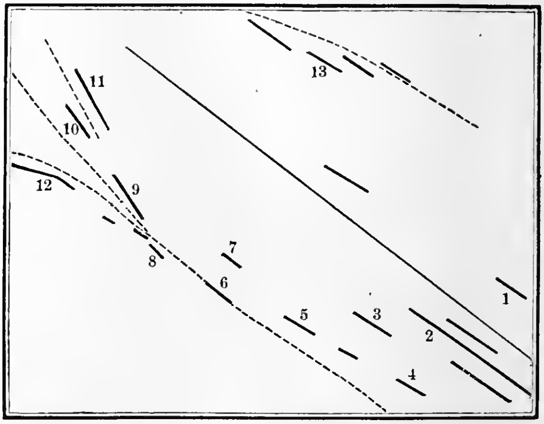


Fig. 35. Polynesian Island Chain.

1, Marquesas; 2, Paumotu; 3, Tahitian; 4, Rurutu group; 5, Hervey group; 6, Samoan, or Navigator's; 7, Vakaafo group; 8, Vaitupu; 9, Kingsmill; 10, Ralick; 11, Radack; 12, Carolines; 13, Sandwich.

The Polynesian Chain consists of a series of parallel chains, extending from the Paumotu and the Tahitian Islands to the Carolines, the Ralick, and the Radack groups. Their general direction is *north-west;* the total length of the chain is about 5500 miles.

The Chain of the Sandwich Islands extends in a north-westerly direction. Its length is about 2000 miles.

The New Zealand Chain extends north-east as far as the Tonga Islands, cutting the Australasian chain at right angles.

96. Isolated Oceanic Islands are mainly of two kinds: the *Volcanic* and the *Coral.* As a rule, the Volcanic islands are high, while Coral islands seldom rise more than twelve feet above the water.

Volcanic Islands are not confined to isolated groups, but occur also in long chains. The Polynesian, Sandwich, and New Zealand Chains contain numerous volcanic peaks. But the *high, isolated oceanic islands are almost always of volcanic origin,* and, consisting of the summits of submarine volcanoes, are generally small. Some of the Canary and Sandwich Islands, which are of this class, rise nearly 14,000 feet above the sea.

97. Coral Islands, or Atolls, though of a great variety of shapes, agree in one particular:

They consist of a low, narrow rim of coral rock, enclosing a body of water called a lagoon.

Fig. 36. A Coral Island.

98. Mode of Formation of Coral Islands.—The reef forming the island is of limestone, derived from countless skeletons of minute polyps that once lived beneath the surface of the waters. The skeletons, however, are not separate. The polyp propagates its species by a kind of budding; that is, a new polyp grows out of the body of the old. In this way the skeletons of countless millions of polyps are united in one mass and assume a great variety of shapes.

One of the most common species of reef-forming corals, the madrepora, is shown in Fig. 37. Many other forms exist.

The delicate coral structures, together with shells from various shellfish, are ground into fragments by the action of the waves, and by the in-

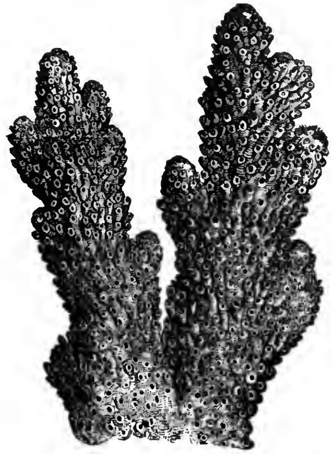


Fig. 37. Coral.

filtration of water containing lime in solution, they become compacted into hard limestone, on which new coral formations grow.

The growth of the coral mass is directed upward, and ceases when low-water mark is reached, because exposure to a tropical sun kills the polyps. But the action of the waves continues, and the broken fragments are gradually thrown up above the general level of the water. In this way a reef is formed, whose height is limited by the force of the waves, and seldom exceeds twelve feet.

On the bare rock, which has thus emerged, a soil is soon formed and a scanty vegetation appears, planted by the hardy seeds scattered over it by the winds and waves.

The coral island never affords a very comfortable residence for man. The palm tree is almost the only valuable vegetable species; the animals are few and small, and the arable soil is limited. Moreover, the island is subject to occasional inundatious by huge waves from the ocean.

99. Distribution of Coral Islands.—According to Dana, the reef-forming coral polyp is found only in regions where the winter temperature of the waters is never lower than 68° Fahr. Some varieties, however, will grow in colder water. *Coral islands are confined to those parts of tropical waters where the depth does not greatly exceed 100 feet, and which are protected from cold ocean-currents, from the influence of fresh river-waters, muddy bottoms, and remote from active volcanoes, whose occasional submarine action causes the death of the coral polyp. Though some coral polyps grow in quiet water, the greater part thrive best when exposed to the breakers. The growth is therefore more rapid on the side toward the ocean than on the side toward the island.*

Coral islands are most abundant *in the Pacific Ocean.* The following groups contain numerous coral islands: the Paumotus, the Carolines, the Radack, the Ralick, and the Kingsmill groups, and the Tahitian, Samoan, and Feejee Islands, and New Caledonia.

In the Indian Ocean the Laccadives and the Maldives are most noted.

In the Atlantic Ocean the West Indies and the Bermudas are examples.

100. Varieties of Coral Formations.—*There are four varieties of coral formations:*

(1.) **Fringing Reefs,** or narrow ribbons of coral rock, lying near the shore of an ordinary island.

(2.) **Barrier Reefs,** which are broader than Fringing Reefs, and lie at a greater distance from the shore, but do not extend entirely around the island.

A barrier reef off the coast of New Caledonia has a length of 400 miles. One extends along the north-eastern shore of Australia for over 1000 miles. Barrier reefs are not continuous, but often have breaks in them through which vessels can readily pass.

(3.) **Encircling Reefs** are barrier reefs extending entirely around the island. As a rule, encircling reefs are farther from the shores of the island than barrier reefs. Tahiti, of the Society Islands, is an example of an encircling reef.

(4.) **Atolls.**—This name is given to reefs that encircle lagoons or bodies of water entirely free from islands.

The varieties of reefs just enumerated mark successive steps or stages in the progress of formation of the coral island.

When a more careful study of the habits of the reef-forming coral polyp disclosed the fact of its inability to live in the ocean at greater depths than 100 or 120 feet, the opinion, which formerly prevailed, of coral islands rising from profound depths, had to be abandoned. The idea had its foundation in the fact that a sounding-line, thrown into the water near the shore of a coral island, almost invariably showed depths of thousands of feet, and yet brought up coral rock. In no case, however, did the rock contain living polyps. An ingenious hypothesis of Darwin, which appears well sustained by the extensive observations of Dana and others, explains the great depth of coral formations.

101. Darwin's Theory of Coral Islands.—According to this distinguished naturalist, the coral formation begins near the shore of an island that is slowly sinking. If the growth of the reef upward equals the sinking of the island, the thickness of the reef is limited only by the time during which the operation continues.

In Fig. 38 is shown, in plan and section, an island with elevations A, and B, and river *a*. The coral island begins as a *fringing reef* somewhere off the coast of an ordinary island at *c, c, c,* when the conditions are favorable. *The*

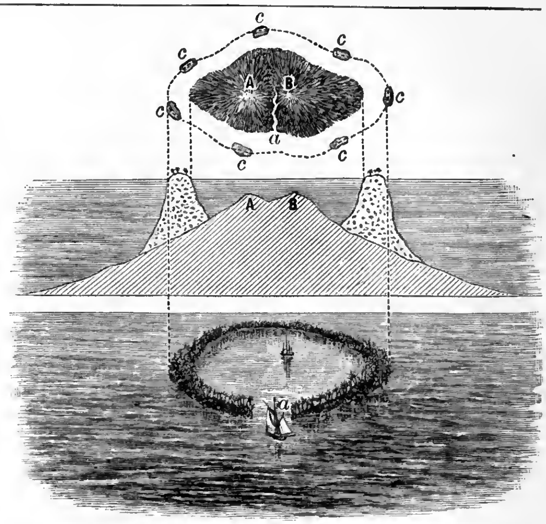


Fig. 38. Growth of a Coral Island.

coral reef must gradually extend around the island, since its growth toward the ocean is soon limited by the increasing depth, and toward the shore of the island by the muddy waters near the surf and the absence of the breakers.

Meanwhile, as the island is sinking, the channel separating the reef from the coast increases in breadth. A *barrier reef* is thus formed, which at last completely surrounds the island, and becomes an *encircling reef.* The higher portions of land, which are still above the waters, form islands in the central lagoon. Opposite the mouth of the river *a*, the growth is prevented by the fresh water, and a break in the reef is thus produced. These breaks are sometimes sufficient to permit a ship to enter the lagoon. At last all traces of the old island disappear, and its situation is marked by a clear lake, surrounded by a narrow rim of coral which follows nearly the old coast line.

A coral island, therefore, is always of an approximately circular or oval form, and encloses a clear space in the ocean. Extended systems of coral formations occurring in any region are a proof of subsidence.

CHAPTER IV.

Relief Forms of the Land.

102. By the Forms of Relief of the Land is meant the elevation of the land above the mean level of the sea.

The highest land in the world is Mount Everest, of the Himalayas; it is 29,000 feet high. The greatest depression is the Dead Sea, in Palestine, which is about 1312 feet below the level of the ocean. The sum of these is somewhat less than six miles.

An elevation of six miles is insignificant when compared with the size of the earth. If represented on an ordinary terrestrial globe, it would be scarcely discernible, since it would project above the surface only about the $\frac{1}{1300}$th of the diameter. The highest elevations of the earth are proportionally much smaller than the wrinkles on the skin of an orange.

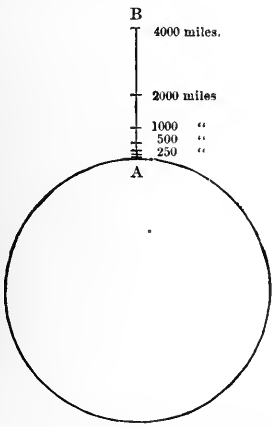


Fig. 39. Relative Height of Mountains.

If, as in Fig. 39, a sphere be drawn to represent the size of the earth, its radius will be equal to about 4000 miles. If, now, the line A B be drawn equal to the radius, it will represent a height of 4000 miles. One-half this height would be 2000 miles; one-half of this 1000, and successive halves 500 and 250 miles. An elevation of 250 miles would not therefore be very marked.

Although the irregularities of the surface are comparatively insignificant, they powerfully affect the distribution of heat and moisture, and consequently that of animal and vegetable life. An elevation of about 350 feet reduces the temperature of the air 1° Fahr.—an effect equal to a difference of about 70 miles of latitude. High mountains, therefore, though under the tropics, may support on their higher slopes a life similar to that of the temperate and the polar regions.

103. The Relief Forms of the Land are divided into two classes:

Low Lands and **High Lands.**

The boundary-line between them is taken at 1000 feet, which is the mean or average elevation of the land.

Low Lands are divided into *plains* and *hills.*

High Lands are divided into *plateaus* and *mountains.*

If the surface is comparatively flat or level, it is called a *plain* when its elevation above the sea is less than 1000 feet, and a *plateau* when its elevation is 1000 feet or over.

If the surface is diversified, the elevations are called *hills* when less than 1000 feet high; and *mountains* when 1000 feet or over.

104. Plains and Hills cover about one-half of the land surface of the earth. In the Eastern Continent they lie mainly in the *north;* in the Western, they occupy the *central portions.*

Plains generally owe their comparatively level surface to the absence of wrinkles or folds in the crust, in which case the general level is preserved, but the surface rises and falls in long undulations: these may therefore be called *undulating plains.*

The flat surface may also be due to the gradual settling of sedimentary matter. In this case the plains are exceedingly level. They are called *marine* when deposited at the bottom of a sea or ocean, and *alluvial* when deposited by the fresh water of a river or lake. Alluvial plains occur along the lower course of the river or near its mouth.

Marine and alluvial plains, from their mode of formation, are generally less elevated than undulating plains.

105. Plateaus are generally found associated with the mountain-ranges of the continents. Their connection with the adjacent plains is either *abrupt,* as where the plateau of Anahuac joins the low plains on the Mexican Gulf; or *gradual,* as where the plains of the Mississippi Valley join the plateaus east of the Rocky Mountains.

106. Mountains. — In a mountain-chain the *crest* or *summit* of the range separates into a number of detached portions called *peaks;* below the peaks the entire range is united in a solid mass.

The breaks in the ridge, when extensive, form *mountain-passes.*

The influence of inaccessible mountains, like the Pyrenees and Himalayas, in preventing the intermingling of nations living on their opposite sides, is well exemplified by history. In the past, mountains formed the boundaries of different races. Some mountains, like the Alps and the Appalachians, have numerous passes.

A Mountain-System is a name given to several connected chains or ranges. Mountain-systems are often thousands of miles in length and hundreds of miles in breadth.

The Axis of a Mountain-system is a line extending in the general trend of its chains.

Where several mountain-axes intersect one another, a complicated form occurs, called a *Mountain-Knot.*

The Pamir Knot, formed by the intersection of the Karakorum, Belor, and Hindoo-Koosh Mountains, is an example. It lies on the southern border of the elevated plateau of Pamir.

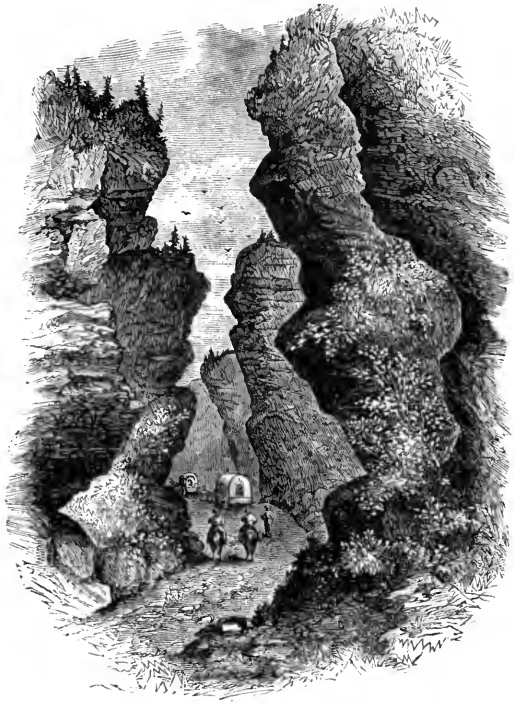


Fig. 40. A Mountain-Pass.

107. Orology treats of mountains and their formation.

The force which upheaved the crust into mountain-masses and plateaus *had its origin in the contraction of a cooling globe.* There are good reasons for believing that no extensive mountains existed during the earlier geological ages, since the crust was then very thin, and would have been fractured before sufficient force could accumulate to upheave it into mountain-masses.

The great mountain-systems of the world are formed from sedimentary deposits that slowly accumulated over extended areas until they acquired very great thickness. The deposits forming the Appalachians, according to Dana, were, in places, 40,000 feet in depth, and covered the eastern border of the continent from New York to Alabama, varying from 100 to 200 miles in breadth.

After the accumulation of these strata they were, through the contraction of the crust, subjected to the gradual effects of lateral pressure, by which they were sometimes merely flexed or folded, but more frequently crushed, fractured, or mashed together, and thus thickened and thrust upward. That side of the deposit from which the thrust came would have a steeper slope than the opposite side, which received a thrust arising from the resistance.

This theory of mountain-formation, which is generally accepted, explains the following facts:

(1.) All mountains have two slopes—a short steep slope, facing the ocean, and a long gentle slope, facing the interior of the continent.

(2.) The strata on the short steep slope are generally highly metamorphosed; those on the long slope are in general only partially metamorphosed, or wholly unchanged.

(3.) The mountain-systems are situated on the borders of the continents where the sedimentary strata collected.

(4.) *Slaty cleavage,* or the readiness with which so many of the rocks of mountains cleave or split in one direction, is a proof of these rocks having been subjected to intense, long-acting, lateral pressure, since such pressure can be made to develop slaty cleavage in plastic material.

Isolated Mountains.—Nearly all high isolated mountains were formed by the ejection of igneous rocks from the interior; that is, they are of volcanic origin and have been upheaved by a vertical strain or true projectile force, as in the volcanic range of Jorullo in Mexico.

108. Valleys in mountainous regions are either *longitudinal* or *transverse.*

Longitudinal Valleys are those that extend in the direction of the length of the mountains.

Transverse Valleys extend across the mountain. It is in transverse valleys that most passes occur.

Although valleys, like mountains, owe their origin to the contraction of a cooling crust, yet their present shapes are modified by the operation of other forces. By the action of their water-courses, valleys are deepened in one place and filled up in another. Extensive land-slides often alter their configuration. During the Glacial Period many valleys were greatly changed by the action of huge moving masses of ice. Fiord-valleys were formed in this manner.

In level countries valleys generally owe their origin to the eroding power of water.

109. Peculiarities of Continental Reliefs.—The following peculiarities are noticeable in the relief forms of the continents:

(1.) *The continents have, in general, high borders and a low interior.*

(2.) *The highest border lies nearest the deepest ocean; hence, the culminating point, or the highest point of land, lies out of the centre of the continent.*

(3.) *The greatest prolongation of a continent is always that of its predominant mountain-system.*

(4.) *The prevailing trends of the mountain-*

masses are the same as those of the coast lines, and are, in general, either north-east or north-west.

In describing the relief forms of the continents we shall observe the following order:

(1.) **The Predominant System,** or a system of elevations exceeding all others in height, and containing the culminating point of the continent.

(2.) **The Secondary System or Systems,** inferior to the preceding in height.

(3.) **The Great Low Plains.**

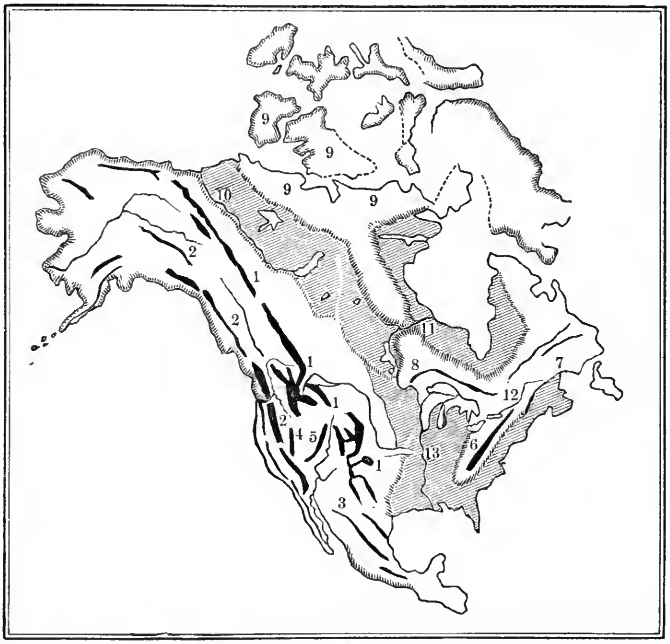


Fig. 41. Orographic Chart of North America. (Light portions, mountains; shaded portions, plains.)

1, Rocky Mountain System; 2, System of the Sierra Nevada and Cascade Ranges; 3, Sierra Madre; 4, Great Interior Plateau; 5, Wahsatch Mountains; 6, Appalachians; 7, Plateau of Labrador; 8, Height of Land; 9, Arctic Plateau; 10, Mackenzie River; 11, Nelson River; 12, St. Lawrence River; 13, Mississippi River.

CHAPTER V.

Relief Forms of the Continents.

I. NORTH AMERICA

110. Surface Structure. — The Predominant Mountain-System lies in the west.

The Secondary Systems lie in the east and north.

The Great Low Plains lie in the centre.

111. The Pacific Mountain-System, the predominant system, extends, in the direction of the greatest prolongation of the continent, from the Isthmus of Panama to the Arctic Ocean. It consists of an immense plateau, from 300 to 600 miles in breadth, crossed by two nearly parallel mountain-systems: the Rocky Mountains on the east and the system of the Sierra Nevada and Cascade ranges on the west. The eastern mountain-system is highest near the south; the western range is highest near the north. Between these lie numerous parallel ranges enclosing longitudinal valleys, connected in places by transverse ranges forming basin-shaped valleys.

The Rocky Mountain System. — The Rocky Mountains rise from the summits of a plateau whose elevation, in the widest part of the system, varies from 6000 to 7000 feet above the sea; therefore, although the highest peaks range from 11,000 to nearly 15,000 feet, their elevation above the general level of the plateau is comparatively inconsiderable. The plateau on the east rises by almost imperceptible slopes from the Mississippi River. The upper parts of the slopes, near the base of the mountains, form an elevated plateau called the "Plains," over which, at one time, roamed vast herds of buffalo or bison. This animal is rapidly becoming extinct.

Though the name "Rocky Mountains" is generally confined to those parts of the chain which extend through British America and the United States, yet, in connection with the Sierra Nevada Mountains, it is continued through Mexico by the Sierra Madre Mountains, and by smaller ranges to the Isthmus of Panama.

Fig. 42. On the Plains.

The Rocky Mountain System forms the great watershed of the continent, the eastern slopes draining mainly through the Mississippi into the Atlantic, and the western slopes draining through the Columbia and the Colorado into the Pacific. It slopes gradually upward from the Arctic Ocean toward the Mexican plateau, where it attains its greatest elevation in the volcanic peak of Popocatepetl, 17,720 feet above the sea.

The System of the Sierra Nevada and Cascade Mountains extends, in general, parallel to the Rocky Mountain System. It takes the name of Sierra Nevada in California and Nevada, and of the Cascade Mountains in the remaining portions of the continent. It reaches its greatest elevation in Mount St. Elias, in Alaska, 19,500 feet above the sea. *This is the culminating point of the North American continent.*

In the broadest part of the plateau of the Pacific system, between the Wahsatch Mountains on the east, and the Sierra Nevada and Cascade ranges on the west, lies the plateau of the Great Basin. Its high mountain borders rob the winds of their moisture, and the rainfall, except on the mountain-slopes, is inconsiderable. The Great Basin has a true inland drainage.

The heights of all mountains, except those much frequented, must generally be regarded as but good approximations, since the methods employed for estimating heights require great precautions to secure trustworthy results. Even the culminating points of all the continents have not, as yet, been accurately ascertained.

112. The Secondary Mountain-Systems of North America comprise the Appalachian system, the Plateau of Labrador, the Height of Land, and the Arctic Plateau. The last three have but an inconsiderable elevation.

The Appalachian Mountain System consists of a number of nearly parallel chains extending from the St. Lawrence to Alabama and Georgia. It is high at the northern and southern ends, and slopes gradually toward the middle. The highest peaks at either end have an elevation of about 6000 feet.

The Appalachian system is broken by two deep depressions, traversed by the Hudson and Mohawk Rivers. Between the foot of the system and the ocean lies a low coast plain, whose width varies from 50 to 250 miles.

113. The Great Low Plain of North America lies between the Atlantic system on the east and the Pacific system on the west. It stretches from the Arctic Ocean to the Gulf of Mexico.

Near the middle of the plain the inconsiderable elevation of the *Height of Land* divides it into two gentle slopes, which descend toward the Arctic Ocean and the Gulf of Mexico. A gentle swell extending from north-west to south-east divides the northern portion of the plain into two parts. The eastern and western basins, so formed, are connected by a break in the watershed, through which the Nelson River empties into Hudson Bay.

The southern part of the plain is traversed, in its lowest parts, by the Mississippi River.

The tributaries of this river descend the long, gentle slopes of the Atlantic and Pacific systems.

114. The Relief Forms of a Continent are best understood by ideal sections, in which the base line represents the sea-level, and the scale of heights on the margin represents the elevation of the various parts.

In all such sections the vertical dimensions of the land are necessarily *greatly* exaggerated.

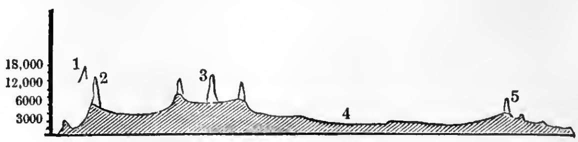


Fig. 43. Section of North America from East to West.
1, St. Elias; 2, Sierra Nevada; 3, Rocky Mountains; 4, Mississippi Valley; 5, Appalachian System.

115. Approximate Dimensions of North America.
Area of continent, 8,400,000 square miles.
Greatest breadth from east to west, about 3100 miles.
Greatest length from north to south, about 4500 miles.
Coast line, 22,800 miles.
Culminating point, Mount St. Elias, 19,500 feet.

Fig. 44. Orographic Chart of South America.
(Light portions, mountains; shaded portions, plains.)
1, System of the Andes; 2, Plateau of Quito; 3, Plateau of Bolivia; 4, Aconcagua; 5, Plateau of Guiana; 6, Plateau of Brazil; 7, The Orinoco; 8, The Amazon; 9, The La Platte.

II. SOUTH AMERICA.

116. Surface Structure. — The Predominant Mountain-System of South America is in the west.

The Secondary Systems are in the east.

The Great Low Plain lies between them.

117. The System of the Andes, which extends along the western border of the continent, *is the predominant mountain-system.* It is composed mainly of two approximately parallel chains separated by wide and comparatively level valleys. On the north there are three chains, and on the south but one; in the centre, mainly two. The chains are connected by transverse ridges, forming numerous mountain-knots.

The Andes System forms a continuation of the Pacific Mountain-System. A wide depression at the Isthmus of Panama marks their separation. From this point the Andes increase in height toward the south, probably reaching their highest point in Chili, where the volcanic peak of Aconcagua, 23,910 feet, is believed to be the *culminating point of South America, and of the Western Continent.*

Nevada de Sorata was formerly believed to be the culminating point of South America, but recent recalculations of the observations have resulted in a loss of nearly 4000 feet of the supposed height of Sorata. Some authorities still claim that several peaks in Bolivia reach an elevation of nearly 25,000 feet.

The Andes Mountain-System terminates abruptly in the precipitous elevations of Cape Horn.

Numerous table-lands are included between the parallel ranges: the most important are—the *plateau of Quito,* 9543 feet; the *plateau of Pasco,* in North Peru, 11,000 feet; the *plateau of Bolivia,* from 12,000 to 14,000 feet. From most of these higher plateaus volcanic peaks arise.

118. The Secondary Mountain-Systems of South America are the *plateaus of Brazil* and *Guiana.* They both lie on the eastern border.

The Plateau of Brazil is a table-land whose average height is about 2500 feet. Narrow chains or ridges separate the river-valleys.

The plateau of Brazil forms the watershed between the tributaries of the Amazon and the La Plata. Along the Atlantic a moderately continuous range descends in steep terraces to the ocean. The average altitude is more than double that of the western portion of the plateau. The highest peaks are somewhat over 8000 feet.

The Plateau of Guiana, smaller than the Plateau of Brazil, but about equally elevated, forms the watershed between the Orinoco and the Amazon.

Fig. 45. Amazon River Scenery.

119. The Great Low Plain of South America lies between the predominant and the secondary mountain-systems. It is mainly of alluvial origin, but slightly elevated, and is much more level than the great plain of North America.

This plain is drained by the three principal river-systems of the continent, by which it is divided into three parts: the *Llanos of the Orinoco, the Selvas of the Amazon, and the Pampas of the La Platte.*

The Llanos are grassy plains which, during the rainy season, resemble our prairies, but during the dry weather are deserts.

The Selvas, or forest plains, are covered by an uninterrupted luxuriant forest. The vegetation here is so dense that in some places the broad rivers form the only ready means of crossing the country. Near the river-banks are vast stretches of swampy ground.

The Pampas are grassy plains which in some respects resemble the Llanos.

A coast plain lies between the Andes and the Pacific. It is widest near the Andes of Chili,

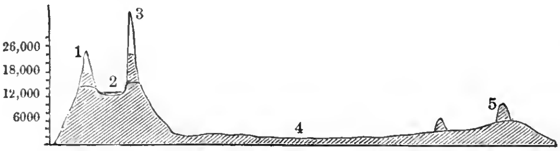


Fig. 46. Section of South America from East to West.

1, Volcano Arequipa; 2, Lake Titicaca; 3, Nevada de Sorata; 4, Central Plain; 5, Mountains of Brazil.

where in some places it is 100 miles in breadth. Between the parallels of 27° and 23° the plain is an absolute desert, called the Desert of Atacama. Here rain never falls and vegetation is entirely absent.

120. Approximate Dimensions of South America.

Area of continent, about 6,500,000 square miles.
Greatest breadth from east to west, 3230 miles.
Greatest length from north to south, 4800 miles.
Coast line, 14,500 miles.
Culminating point, Aconcagua, 23,910 feet.

121. Contrasts of the Americas.—In both North and South America *the predominant system lies in the west, the secondary systems in the east, and the low plains in the centre.*

They differ in the following respects:

In North America the *predominant system is a broad plateau,* having high mountain-ranges; *the principal secondary system is narrow,* and formed of parallel ranges; *the low plains* are characterized by *undulations, and contain several deep depressions* occupied by extensive lake-systems.

In South America the *predominant system is narrow; the secondary systems are broad; the low plain* is *alluvial, extremely flat, contains no depressions,* and consequently no extensive lake-systems.

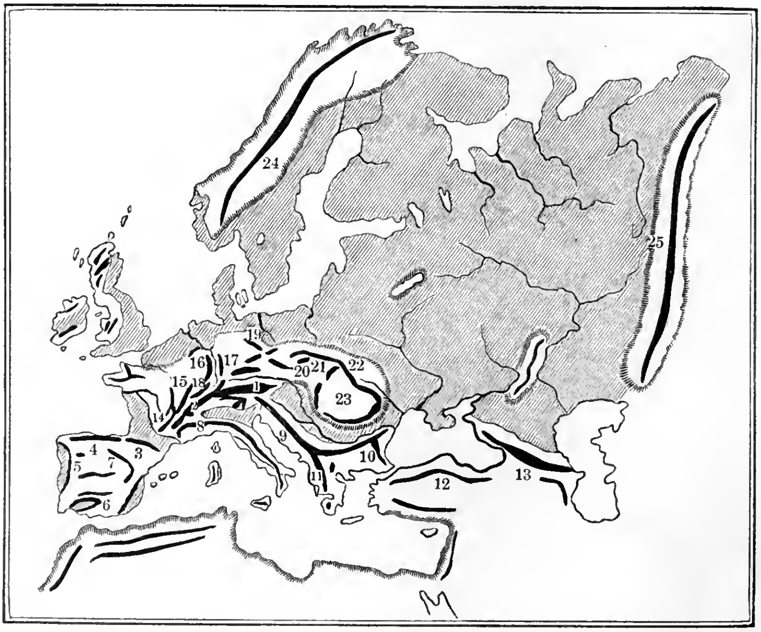


Fig. 47. Orographic Chart of Europe. (Light portions, mountains; shaded portions, plains.)

1, The Alps; 2, Mont Blanc; 3, Pyrenees; 4, Cantabrian; 5, Sierra Estrella; 6, Sierra Nevada; 7, Mountains of Castile; 8, Apennines; 9, Dinaric Alps; 10, Balkan; 11, Pindus; 12, Taurus; 13, Caucasus; 14, Cevennes; 15, Plateau of Auvergne; 16, Vosges; 17, Black Forest; 18, Jura; 19, Hartz; 20, Bohemian Plateau; 21, Carpathians; 22, Hungarian Forest; 23, Transylvanian Mountains; 24, Kiolen Mountains; 25, Urals.

III. EUROPE.

122. Surface Structure.—The Predominant Mountain-System is in the south.

The Secondary Systems are in the north and east.

The Great Low Plain lies between the Predominant and Secondary Systems.

A line drawn from the Sea of Azov to the mouth of the Rhine River divides Europe into two distinct physical regions. The great low plain lies on the north, and the predominant mountain-system on the south. The country north of this line is sometimes called *Low Europe*, and that south of it, *High Europe*.

123. The Predominant Mountain-System of Europe is composed of a highly complex series of mountain-systems extending along the northern shores of the Mediterranean in a curve, from the Straits of Gibraltar to the shores of Asia Minor. The system is highest in the centre, where the *Alps* form the culminating point of the continent.

The average elevation of the Alps ranges from 10,000 to 12,000 feet. The highest peak, *Mont Blanc, 15,787 feet, is the culminating point of the European continent. Matterhorn* and *Monte Rosa* are but little inferior in height. On the south-west the system is continued to the Atlantic by the Cevennes and adjoining ranges in France, and the Pyrenees and Cantabrian in the northern part of the Spanish peninsula. The Pyrenees are an elevated range, with peaks over 11,000 feet high. On the east the system extends in two curves to the Black Sea by the Carpathian and Transylvanian Mountains on the north, and the Dinaric Alps and the Balkan Mountains on the south.

124. Divisions of Predominant System.—The predominant mountain-system of Europe may be conveniently regarded as consisting of a central body or axis, the *Alps*, with six projections or limbs—three on the north, and three on the south.

The three divisions on the north include—

The Western Division, or the mountains of France, including the mountains lying west of the valleys of the Rhine and the Rhone;

The Central Division, or the mountains of Germany, situated between the Western Division and the upper valleys of the Oder and the Danube;

The Eastern Division, or the mountains of Austria-Hungary, situated between the Central Division and the Black Sea.

These divisions contain a highly complicated system of minor elevations. Their complexity is due to the frequent intersection of the north-eastern and north-western trends. Basin-shaped plateaus, like the Bohemian and Transylvanian, are thus formed.

The Western Division includes most of the mountains of France, as the Cevennes, the mountains of Auvergne, and the Vosges Mountains.

The Central Division includes the Jura Mountains in Switzerland, the Swiss and the Bavarian plateaus, the Black Forest Mountains, the Hartz Mountains, and the Bohemian plateau.

The Eastern Division includes most of the mountains of Austria, as the Carpathians, the Hungarian Forest, and the Transylvanian Mountains.

125. The three projections on the south are the three mountainous peninsulas of Southern Europe:

The Iberian Peninsula, including Spain and Portugal;

The Italian Peninsula;

The Turco-Grecian Peninsula.

The Iberian Peninsula.—The principal mountains are the Sierra Estrella, the mountains of Castile, and the Sierra Nevada. The Pyrenees separate the Peninsula from France. The Cantabrian Mountains extend along the northern coast.

The Italian Peninsula contains the Apennines, extending mainly in the direction of the north-western trend.

The Turco-Grecian Peninsula.—The Dinaric Alps extend along the coast of the Adriatic; the Balkan Mountains extend from east to west, through Turkey; and the Pindus from north to south, through Turkey and Greece.

126. The Secondary Mountain-Systems of Europe comprise the system of the Scandinavian peninsula, the Ural Mountains, and the Caucasus Mountains.

The System of the Scandinavian Peninsula includes the elevations of Norway and Sweden. With the exception of the Kiolen Mountains in the north, the system does not embrace distinct mountain-ridges, but consists mainly of a series

Fig. 48. Fiord on Norway Coast.

of broad plateaus that descend abruptly on the west in numerous deeply-cut valleys called *fiords*, through which the sea penetrates nearly to the heart of the plateaus. Fiords are valleys that were deeply eroded by slowly moving masses of ice, called glaciers, and subsequently partially submerged. On the east the slopes are more gradual, and are occupied by numerous small lakes.

The System of the Urals is composed of a moderately elevated range extending from the Arctic Ocean on the north to the plains of the Caspian on the south. The elevated island of Nova Zembla may be considered as forming a part of its northern prolongation.

The Caucasus Mountains bear peaks exceeding in elevation those of the Alps. They belong, however, more properly to the elevations of Asia.

127. The Great Low Plain of Europe lies between the predominant and secondary mountain-systems, and stretches north-eastwardly from the Atlantic to the Arctic. It is remarkably level, and is highest in the middle, where the Valdai Hills form the principal watershed of Europe. Westward the plain is continued under the North Sea to the British Isles, where a few inconsiderable elevations occur.

South of the Alps the large plain of the Po River stretches across the northern part of Italy.

128. Approximate Dimensions of Europe.

Area of continent, 3,700,000 square miles.

Coast line, 19,500 miles.

Greatest breadth from north to south, 2400 miles.

Greatest length from north-east to south-west, 3370 miles.

Culminating point, Mont Blanc, 15,787 feet.

Fig. 49. Orographic Chart of Asia. (Light portions, mountains; shaded portions, plains.)

1, Himalaya Mountains; 2, Karakorum; 3, Kuen-lun; 4, Belor; 5, Thian Shan; 6, Altai; 7, Great Kinghan; 8, Yablonoi; 9, Nanling; 10, Peling; 11, Vindhya; 12, Ghauts; 13, Hindoo-Koosh; 14, Elburz; 15, Suliman; 16, Zagros; 17, Taurus; 18, Caucasus; 19, Asiatic Island Chain.

IV. ASIA.

129. Surface Structure. — The Predominant Mountain-System is in the south.

The Secondary Systems surround the Predominant System.

The Great Low Plain is on the north and west, and lies between the mountain-systems of Asia and the secondary system of the Urals.

Europe and Asia are sometimes considered as geographically united in one grand division called *Eurasia*.

130. The mountain-systems of Asia are nearly all connected in one huge mass which extends *in* *the line of the north-east trend,* from the Arctic to the Indian Ocean. Though in reality *one vast system,* yet they are most conveniently arranged in *one predominant and several secondary systems.*

The Predominant System is the *plateau of Thibet,* the loftiest table-land in the world. It is between 15,000 and 16,000 feet high, and is crossed by three huge, nearly parallel, mountain-ranges: the *Himalayas* on the south, the *Kuen-lun* on the north, and the *Karakorum* between them. The Himalayas, the loftiest mountains

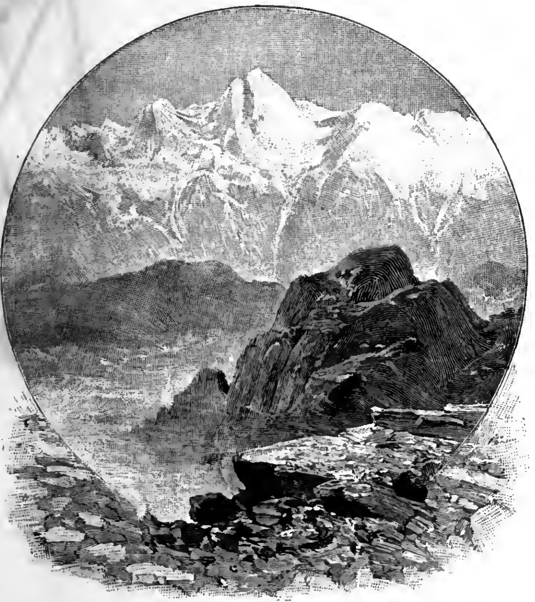


Fig. 50. Himalaya Mountains.

in the world, rise abruptly from the plains of Northern Hindostan. Like the Alps, their axis is curved, but in the opposite direction. The breadth of the system varies from 100 to 200 miles; the length is about 1500 miles. *The highest point is Mount Everest, 29,000 feet above the sea; it is the culminating point of the Asiatic continent and of the world.* Kunchinjunga and Dhawalaghiri are scarcely inferior in height.

131. The Secondary Systems lie on all sides of the predominant system, though mainly on the north and east of the predominant system. Like Europe, the Asiatic continent projects on the south in the three mountainous peninsulas of Arabia, Hindostan, and Indo-China.

On the north and east of the plateau of Thibet is an extended region called *the plateau of Gobi,* considerably lower than the surrounding country. The *Kuen-lun* and *Great Kinghan Mountains* bound it on the south and east, and the *Altai Mountains* on the north. On the west lie the *Thian Shan* and *Altai,* which by their open valleys afford ready communication with the low plains on the west.

The plateau of Gobi varies in average height from 2000 to 4000 feet. The greatest depression is in the west, and is occupied by Lake Lop and the Tarim River. A small part of the region near the mountain-slopes is moderately fertile, the remainder is mainly desert.

The Altai Mountains are but little known, but some of their peaks exceed 12,000 feet. They are continued eastward by the *Yablonoi Mountains.* East of the plateau of Gobi a range extends north-easterly through Mantchooria.

On the south and west of Thibet lie the plateaus of Iran, Armenia, and Asia Minor.

The Plateau of Iran includes Persia, Afghanistan, and Beloochistan. It is a basin-shaped region from 3000 to 5000 feet high. The *Elburz* and *Hindoo-Koosh* Mountains form its borders on the north, the *Suliman* on the east, and the *Zagros* on the south and west.

The Suliman Mountains rise abruptly from the plains of the Indus. Across these mountains occurs the only practicable inland route between Western Asia and the Indies.

The Plateaus of Armenia and of Asia Minor lie west of the Plateau of Iran. Armenia is 8000 feet high, and bears elevated mountains: Mount Ararat, 16,900 feet, is an example. On the west, the peninsula of Asia Minor, or Anatolia, extends between the Black and Mediterranean Seas, and is traversed by the Taurus Mountains.

The Caucasus Mountains lie north of the plateau of Armenia. They are an elevated range extending between the Black and Caspian Seas, and form part of the boundary-line between Europe and Asia. Mount Elburz, the "Watch-Tower," the culminating peak, is 18,493 feet high.

The Arabian Plateau occupies the entire peninsula of Arabia. It is separated from the plateau of Iran by the Persian Gulf and the valleys of the Tigris and the Euphrates.

The Plateau of Deccan occupies the lower part of the peninsula of Hindostan. It is crossed on the north by the Vindhya Mountains, and along the coasts by the Eastern and Western Ghauts.

The Peninsula of Indo-China is traversed by a number of mountain-ranges which diverge from the eastern extremity of the Himalayas. The *Nanling* and *Peling* extend from east to west through China.

132. The Great Low Plain is, in reality, but a continuation of the European plain. It extends from the Arctic Ocean south-westerly to the Caspian and Black Seas. It is hilly on the east, but level on the west. South of the 60th parallel it is comparatively fertile. Around the shores of the Arctic are the gloomy Tundras.

The Tundras are vast regions which in summer are covered with occasional moss-beds, huge shallow lakes, and almost interminable swamps, and in winter with thick ice. The tundras are caused as follows: The rivers that flow over the immense plain of Asia rise in the warmer regions on the south. Their upper courses thawing while the lower courses are still ice-bound, permits large quantities of drift ice to accumulate at their mouths, which, damming up the water, causes it to overflow the adjoining country.

Depressions of the Caspian and Sea of Aral.—Two remarkable depressions occur in the basins of the Caspian and Sea of Aral, and that of the Dead Sea. These are all considerably below the level of the ocean. The waters of the Caspian and Sea of Aral were probably once connected in a great inland sea.

The Smaller Asiatic Plains are drained by several river-systems. These are the Plain of *Mantchooria*, drained by the Amoor; the Plain of *China*, drained by the Hoang-Ho and the Yang-tse-Kiang; the Plain of *India*, drained by the Indus, the Ganges, the Brahmapootra, and the Irrawaddy; and the Plain of *Persia*, drained by the Tigris and the Euphrates.

133. Approximate Dimensions of Asia.
Area of continent, 17,500,000 miles.
Coast line, 35,000 miles.
Greatest length from north-east to south-west, 7500 miles.
Greatest breadth from north to south, 5166 miles.
Culminating point, Mount Everest, 29,000 feet.

134. Comparison of the Relief Forms of Europe and Asia.—In both Europe and Asia the chief elevations are in the south and the great low plains in the north. Asia, like Europe, extends toward the south in three great peninsulas: Arabia, Hindostan, and Indo-China.

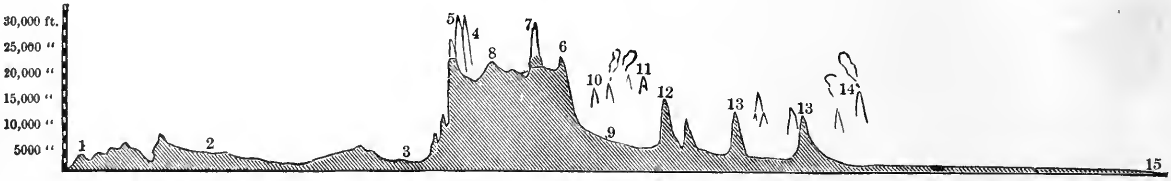


Fig. 51. Section of Asia from North to South.
1, Cape Comorin; 2, Deccan; 3, Plain of India; 4, Himalayas; 5, Everest; 6, Kuen-lun; 7, Karakorum; 8, Thibet; 9, Upper Tartary; 10, Ararat; 11, Elburz; 12, Thian Shan; 13, Altai; 14, Mountains of Kamtchatka; 15, Arctic Ocean, mouth of Yenesei.

Fig. 52. Orographic Chart of Africa.
(Light portions represent mountains; shaded portions, plains.)
1, Abyssinian Plateau; 2, 3, Kenia and Kilimandjaro; 4, Lupata; 5, Dragon; 6, Nieuveldt; 7, Mocambe; 8, Crystal; 9, Cameroons; 10, Kong; 11, Atlas; 12, Lake Tchad; 13, Madagascar.

V. AFRICA.

135. Surface Structure.—Nearly the entire continent of Africa is a moderately elevated plateau. It therefore has no great low plains; but the interior is lower than the marginal mountain-systems, and in this respect the true continental type, *high borders and a low interior, is preserved.*

136. The Predominant Mountain-System is in the east.

The Secondary Systems are in the south, west, and north.

The great interior depression is in the middle, and is surrounded by the predominant and secondary systems.

A narrow, low plain extends along most of the coast. It is broadest on the north-west, between the plateau of the Sahara and the Atlas Mountain-system.

137. The Predominant Mountain-System extends along the entire eastern shore, from the Mediterranean Sea to the southern extremity of the continent. It is highest near the centre, in the *plateaus of Abyssinia and Kaffa.* The culminating point is probably to be found in the volcanic peaks of Kenia and Kilimandjaro, whose estimated heights are taken at about 19,000 feet. In the Abyssinian plateau, on the north, an average elevation of from 6000 to 8000 feet occurs. Upon this, rising in detached groups, are peaks the highest of which are over 15,000 feet.

From the Abyssinian plateau the system is continued northward to the Mediterranean by a succession of mountains which stretch along the western shores of the Red Sea. Some of the peaks are from 6000 to 9000 feet. South of the *plateau of Kaffa* the system is continued by the *Lupata and Dragon Mountains* to the southern extremity of the continent. The Zambesi and Limpopo Rivers discharge their waters into the Indian Ocean through deep breaks in the system.

138. Secondary Systems.—*On the south* the *Nieuveldt and Snow Mountains* stretch from east to west, with peaks of over 10,000 feet. Table Mountain is on the south.

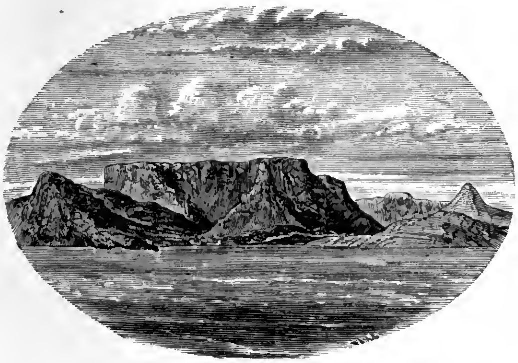


Fig. 53. Table Mountain.

On the west the Mocambe and Crystal Mountains extend from the extreme south to the Gulf of Guinea. Near the northern end of this range, but separate from it, are the volcanic peaks of the *Cameroons Mountains,* 13,000 feet high.

The Kong Mountains extend along the northern shores of the Gulf of Guinea in a general east-and-west direction. Some of the peaks are snow-capped. In the extreme north of Africa are the *Atlas Mountains,* which rise from the summit of a moderately elevated plateau. Some of the peaks are 13,000 feet high.

139. The Great Interior Depression north of the equator is divided into two distinct regions. A straight line extending from Cape Guardafui to the northern shores of the Gulf of Guinea marks the boundary. The mountain-systems north of this line have a general east-and-west direction; those south of it have a general north-and-south direction.

The Plateau of the Sahara occupies the northern part of the interior depression. Its general elevation is about 1500 feet, though here and there plateaus of from 4000 to 5000 feet occur, and even short mountain-ranges with peaks of 6000 feet. The main portion of the region is covered with vast sand-fields, with occasional rocky masses, and is one of the most absolute deserts in the world.

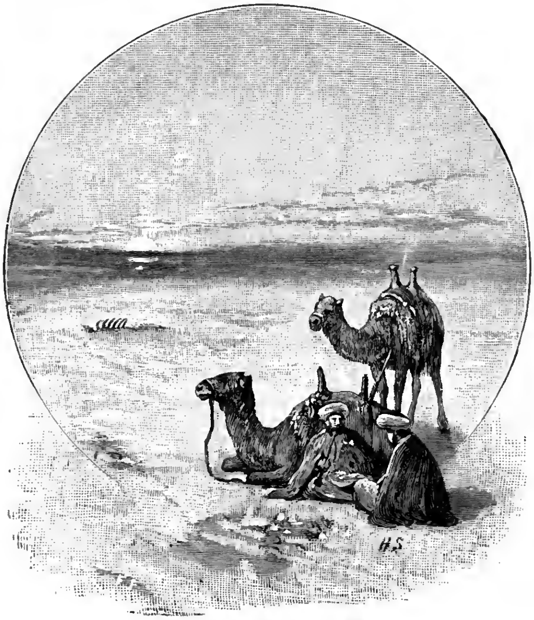


Fig. 54. Desert of Sahara.

Near long. 14° E. from Greenwich, in the district of Fezzan, the plateau is divided from north to south by a broad valley. In this occur many remarkable depressions, some of which are several hundred feet below the level of the Mediterranean. Here fertile spots, called *oases,* are common.

South of the Sahara is the *Soudan,* a remarkably well-watered and fertile region. Lake Tchad occupies the greatest depression. The interior, which lies south of this, is but little known. It is probably a moderately elevated plateau. Extensive lake-basins—Albert and Victoria Nyanzas and Tanganyika—lie near the predominant mountain-system.

140. Approximate Dimensions of Africa.

Area of continent, 12,000,000 square miles.
Coast line, 16,000 miles.
Greatest breadth from east to west, 4800 miles.
Greatest length from north to south, 5000 miles.
Culminating point, Mount Kenia, or Kilimandjaro, about 19,000 feet.

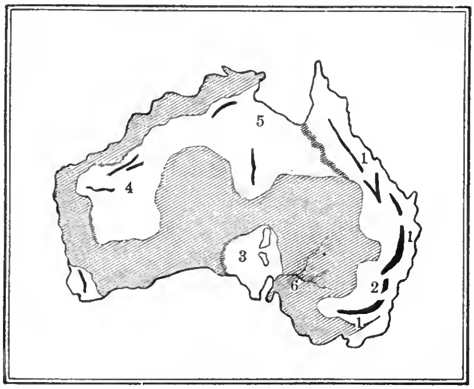


Fig. 55. Orographic Chart of Australia.
(White portions, mountains; shaded portions, plains.)
1, Australian Alps; 2, Kosciusko; 3, 4, 5, Secondary Systems; 6, Murray River.

VI. AUSTRALIA.

141. Surface Structure. — The Predominant Mountain-System is in the east.

The Secondary Systems are in the west and north-west.

The Great Low Plain lies between the predominant and secondary systems, and slopes gently to the southern coast.

The Predominant System extends along the entire eastern shore, from Torres Straits to the southern extremity of Tasmania. It is for the most part composed of broad plateaus. The system is highest in the south-east, where the name Australian Alps is given to the range. *Mount Kosciusko, 7000 feet, probably forms the culminating point of the Australian continent.*

The system descends abruptly on the east, but on the west it descends by gentle slopes to the low plains of the interior.

142. The Secondary Systems, on the west and north-west, are of but moderate elevation.

143. The Great Low Plain lies in the interior. Accurate information as to its peculiarities is yet wanting. A moderate elevation on the north connects the eastern and western systems. The south-eastern portion, which is the best known, is well watered and remarkably fertile. Basin-shaped valleys are found in the west. The lower parts are occupied by Lake Eyre, Torrens, and Gairdner.

144. Approximate Dimensions of Australia.
Area of continent, 3,000,000 square miles.
Coast line, 10,000 miles.
Greatest length from east to west, 2400 miles.
Greatest breadth from north to south, 2000 miles.
Culminating point, Mount Kosciusko, 7000 feet.

145. Contrasts of Africa and Australia.—In the *north*, the *African continent resembles Europe and Asia* in the arrangement of its forms of relief. In the *south*, it resembles the *Americas*. As a whole, the African continent *resembles Australia* more closely than any other. In both

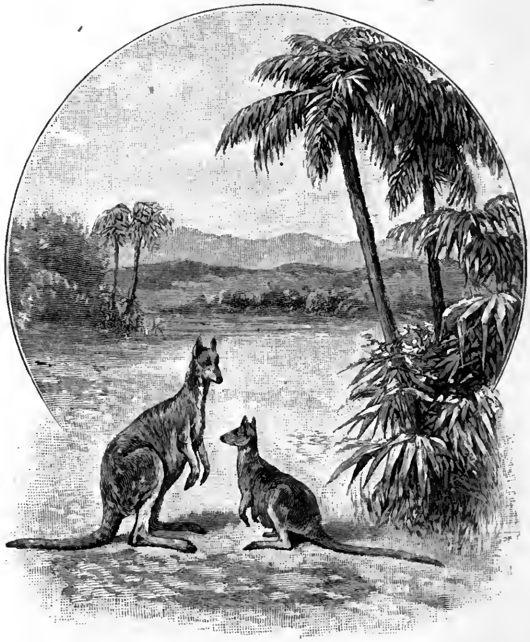


Fig. 56. Australian Scenery.

Africa and Australia the predominant system is in the *east*, and extends along the entire coast. In each the secondary systems are in the *west and north*. But Africa terminates in a *plateau which descends abruptly to the sea*, while Australia is *terminated by a great low plain which descends by long, gentle slopes from the interior.*

SYLLABUS.

Rock-masses are divided, according to their *origin*, into *igneous*, *aqueous*, and *metamorphic*. According to their *condition*, into *stratified* and *unstratified*. According to the presence or absence of organic remains, into *fossiliferous* and *non-fossiliferous*. Stratified rocks are sometimes called *fragmental*. Unstratified rocks are sometimes called *crystalline*. Aqueous rocks are sometimes called *sedimentary*.

Aqueous rocks are stratified. Igneous rocks are unstratified. Metamorphic rocks were originally stratified, but lost their stratification through metamorphism.

Aqueous rocks may contain fossils. Igneous rocks never contain fossils. Metamorphic rocks, in rare instances, may contain fragments of fossils.

Geological time is divided into *Archæan*, *Palæozoic*, *Mesozoic*, and *Cenozoic*.

Archæan Time includes the Azoic and the Eozoic Ages.

Palæozoic Time, or, as it is sometimes called, the Primary, includes the Silurian, Devonian, and Carboniferous Ages.

Mesozoic Time, or the Secondary, includes the Age of Reptiles.

Cenozoic Time includes the Age of Mammals, or the Tertiary, and the Era of Man, or the Quaternary Age.

The changes to which the earth's crust is now subject are produced by the following agencies:

1. By the winds; 2. By the moisture of the atmosphere; 3. By the action of running water; 4. By the action of ocean waves; 5. By the agency of man; 6. By the contraction of a cooling crust.

There is more water than land surface on the earth, in proportion of 25 : 9, or as $5^2 : 3^2$.

The land-masses surround the north pole in the shape of an irregular ring.

Nearly all the land-areas are collected in one hemisphere, and the water-areas in another.

The Land Hemisphere comprises the whole of North America, Europe, and Africa, all of Asia except a small part of the Malay Peninsula, and the greater part of South America.

The Water Hemisphere comprises the whole of Australia and the southern portions of South America and the Malay Peninsula.

The northern continents are almost entirely in the temperate latitudes; the southern are mainly in the tropics.

The land-masses may be divided into three doublets, consisting of pairs of northern and southern continents, almost or entirely separated from each other.

There are two great systems of trends or lines of direction, along which the continents, the coast lines, the mountain-ranges, the oceanic basins, and the island chains are arranged. These trends are north-east and north-west.

The northern continents are characterized by deeply indented coast lines; the southern are comparatively simple and unbroken. Europe is the *most*, and Africa the *least*, deeply indented of the continents.

In proportion to her area, Europe has three times as much coast line as Asia, and four times as much as Africa.

One-seventeenth of the land-area is composed of islands.

Islands are either continental or oceanic.

There are four successive stages in the formation of a coral island or atoll: 1. The fringing reef; 2. The barrier reef; 3. The encircling reef; 4. The coral island or atoll.

The greatest elevations and depressions in the earth's surface are small when compared with its size.

Low lands are either plains or hills.

High lands are either plateaus or mountains.

Plains are—1. Undulating; 2. Marine; 3. Alluvial.

Mountains were produced by the contraction of the crust, producing a lateral pressure on thick, extended deposits of sedimentary rocks. Slaty cleavage was caused by this lateral pressure.

Valleys are either longitudinal or transverse.

All continents have high borders and a low interior. The highest border faces the deepest ocean.

The greatest prolongation of a continent is that of its predominant mountain-system. The culminating point is always out of the centre.

North and *South America* resemble each other in the arrangement of their relief forms. Their predominant systems are in the west; their secondary systems are in the east; their great low plains are between the predominant and secondary systems.

The predominant system of North America is the Pacific mountain-system. The secondary systems are—the Appalachian system, the plateau of Labrador, the Height of Land, and the Arctic plateau.

The predominant system of South America is the system of the Andes. The secondary systems are—the plateaus of Guiana and Brazil. The great low plains are—the Llanos of the Orinoco, the Selvas of the Amazon, and the Pampas of the La Plata.

Europe and *Asia* resemble each other. Their predominant systems are in the south; their great low plains are north of their predominant systems. The predominant system of Europe is in the south.

The secondary systems are—the mountains of the Scandinavian Peninsula, the Ural Mountains, and the Caucasus Mountains.

The predominant mountain-system of Asia is the plateau of Thibet.

The secondary systems are—the plateau of Gobi, the Thian-Shan and Altai Mountains, the plateau of Indo-China, the plateau of Deccan, the plateau of Iran, the plateau of Asia Minor, and the plateau of Arabia.

Africa and *Australia* resemble each other. Their predominant systems are in the east; their secondary systems are in the west and north; their depressed areas are between the two.

The predominant mountain-system of Africa includes the mountains of the eastern coast.

The secondary systems include the Nieuveldt and Snow Mountains in the south, the Mocambe, Crystal, Cameroons, and Kong Mountains in the west, and the Atlas Mountains in the north.

The predominant mountain-system of Australia includes the mountains of the eastern coast.

The secondary systems include those found in the south, west, and north.

REVIEW QUESTIONS.

What two elementary substances form the greater part by weight of the earth's crust?

Into what classes may rocks be divided according to their condition? According to their origin? According to the presence or absence of fossils?

What is palæontology?

Define Archæan Time, Palæozoic Time, Mesozoic Time, and Cenozoic Time.

Explain the nature of the changes which the atmosphere is now effecting in the earth's surface. Which the water is effecting. Which man is effecting.

What must be the areas of two squares whose areas represent the *relative* land- and water-areas of the earth? What are the *actual* areas in square miles?

How would you draw a circle around the earth which will divide it into land and water hemispheres?

Do the continents extend farther to the north pole or to the south pole?

What do you understand by lines of trend?

Which have the more diversified coast lines, the northern or the southern continents?

Define continental and oceanic islands, and give examples of each. Why are continental islands to be regarded as detached portions of the neighboring mainland?

Name the American island chains. The Asiatic chains.

Describe the Australasian island chain. The Polynesian chain.

Which are the higher, volcanic islands or coral islands? Why?

Name the four principal steps or stages in the progress of formation of a coral island.

Is the coral island built by the coral animalcule or by the waves? Explain your answer.

What is Darwin's theory for the presence of a lagoon within the reef?

What is the difference between a plain and a plateau? A mountain and a hill?

Define mountain-system. A chain. A knot.

What is the name of the highest plateau in the world? Of the largest plain?

In what different ways were plains formed?

Distinguish between a longitudinal and a transverse valley. Explain the manner in which mountains were formed.

Give a short account of the surface structure, or the arrangement of the high and low lands, of North America. Of South America. Of Europe. Of Asia. Of Africa, and of Australia. Which of these resemble each other? In what respect do they all resemble one another?

Name the culminating points of each of the continents.

Name the predominant and secondary mountain-systems of each of the continents.

How many times larger is Asia than Australia? Than Europe? Africa? North America? South America?

North America.

Name the principal mountains of the Pacific mountain-system. Which contains the culminating point of the continent?

Where is the Great Basin? By what mountains is it surrounded?

Name the principal mountains of the Appalachian system.

Is the greater portion of the area of North America *above* or *below* 1000 feet?

What rivers drain the great low plain of North America?

South America.

Name the principal plateaus of the Andes. Through which does the equator pass? Which contains Lake Titicaca?

Where is the plateau of Guiana? Of Brazil?

What three large river-systems drain the great low plain of South America? What resemblances can you find between the directions of these rivers and those which drain North America?

Europe.

Describe the chain of the Alps.

What river-systems divide its northern slope into three divisions? Name the principal mountains of each division.

What three peninsulas project southward from the southern slopes of the predominant mountain-system?

Name the principal mountains of each peninsula.

Name the great low plains of Europe.

Asia.

What mountains form the northern boundary of the plateau of Thibet? The southern boundary? The northern boundary of the plateau of Mongolia? The eastern boundary? What mountains extend through China?

What mountains form the boundaries of the plateau of Iran? Is Arabia a plateau or a plain?

Is the land north of the Sea of Aral high or low?

In which line of trend do the mountainous elevations of Asia extend?

Africa.

What portions of Africa are high? What portions are low?

Where is the predominant system? Where is the culminating point? What part of the interior is low?

Where are the Mocambe Mountains? The Crystal Mountains, the Cameroons, the Atlas, the Kong, the Lupata, and the Dragon?

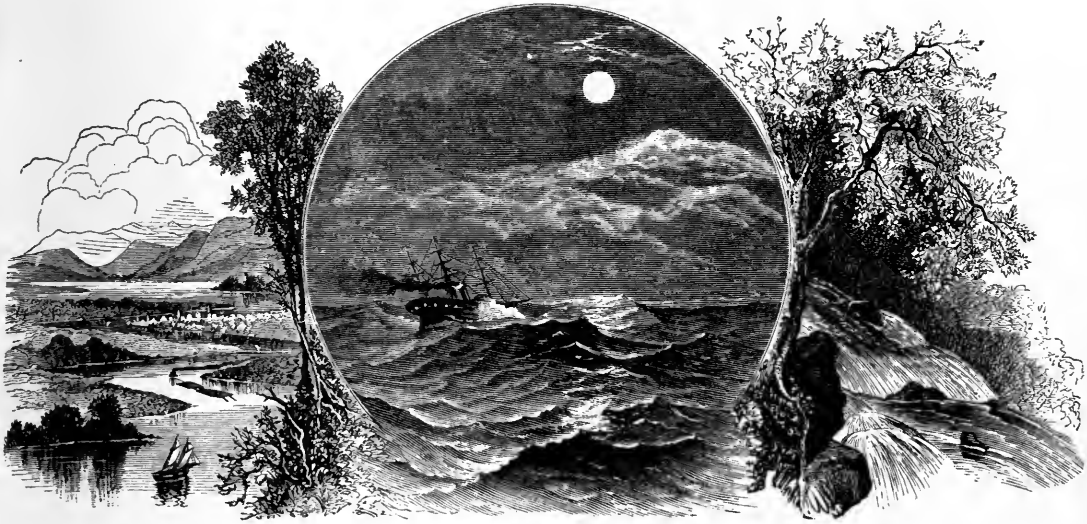
Australia.

Where is the predominant mountain-system? The secondary system?

Where is Mount Kosciusko? The Murray River?

PART III.

THE WATER.



BY contact of air with the water-areas, an immense quantity of invisible vapor passes into the atmosphere, from which, when sufficiently cooled, it re-appears and descends as fog, dew, rain, hail, sleet, or snow. It then, in greater part, drains through various lake- and river-systems into the ocean, where it is either again evaporated, or carried about in waves, tides, or currents. *This circulation of water* never ceases, and *upon it depends the existence of all life on the earth.*

SECTION I.

CONTINENTAL WATERS.

CHAPTER I.

Physical Properties of Water.

146. Composition.—Water is formed by the combination of *oxygen* and *hydrogen*, in the proportion, by weight, of eight parts of oxygen to one part of hydrogen; or, by volume, of one part of oxygen to two parts of hydrogen.

147. Properties.—Pure water is a colorless, transparent, tasteless, and inodorous liquid. It freezes at 32° Fahr., and, under the ordinary pressure of the atmosphere, boils at 212° Fahr.

Water exists in three states: *solid, liquid,* and *gaseous.* Under ordinary circumstances it freezes at 32°. It evaporates, or passes off from the surface as vapor, *at all temperatures,* even at 32°; but it is only at the boiling-point that the vapor escapes from the *mass* of the liquid as well as from the surface.

Heated in open vessels, under the ordinary pressure of the atmosphere, *its temperature cannot be raised higher than* 212°, any increase of heat only causing it to boil more rapidly. Heated in closed vessels, which prevent the escape of steam, its temperature can be raised very high. In such cases great pressure is exerted on the walls of the vessel. Conversely, on high mountains, where the pressure of the atmosphere is lower than at the level of the sea, water boils at temperatures lower than 212° Fahr.

148. Maximum Density of Water.—A pint of cold water is heavier than a pint of warm water, because as water is cooled it contracts and grows denser. The coldest pint of water, however, is not the heaviest. The heaviest pint of water is water at the temperature of 39.2° Fahr. This temperature is therefore called the temperature of the maximum density of water. If water at this temperature be heated, it becomes lighter, or expands; if water at this temperature be cooled, it also becomes lighter or expands until ice is formed, which floats on the water. When at the temperature of its maximum density, water is 7.2° warmer than the freezing-point.

149. Effect of the Maximum Density of Water on its Freezing.—If water continued to contract indefinitely while cooling until freezing began, the ice first formed would sink to the bottom, and, this process continuing, the entire mass would soon become solid. In this manner all bodies of fresh water, in times of great cold, might freeze throughout; when, not even the heat of a tropical sun could entirely melt them.

But for this curious exception in the physical properties of water, at least three-fourths of the globe would be incapable of sustaining its present life.

The entire floor of the ocean, both in the tropics and in the temperate and the polar regions, is covered with a layer of cold, salt water at nearly the temperature of its maximum density. In the tropics the surface-water is warmer and lighter than this dense layer, and in the polar regions it is colder and lighter.

150. Specific Heat of Water.—Another remarkable property of water—*its specific heat*—enables it to play an important part in the economy of the world.

The specific heat of a body is the quantity of heat-energy required to produce a definite increase of temperature in a given weight of that body.

Water has a very great specific heat; that is, *a given quantity of water requires more heat-energy to warm it, and gives out more heat-energy on cooling, than an equal quantity of any other common substance.*

The quantity of heat required to raise a pound of ice-cold water to 212°, would heat a pound of *ice-cold iron to a bright red heat,* or to about 1600° Fahr.; or, conversely, a pound of boiling water cooling to the freezing-point, would give out as much heat as a pound of red-hot iron cooling to 32° Fahr.

The enormous capacity of water for heat is of great value to the life of the earth. The oceanic waters are vast reservoirs of heat, storing heat in summer and giving it out in winter. The great specific heat of water prevents it from either heating or cooling rapidly. Large bodies of water, therefore, prevent great extremes of heat and cold.

151. Heat Absorbed or Emitted during Change of State.—During the conversion of a solid into a liquid, or a liquid into a vapor, a large quantity of heat-energy is absorbed. This heat-energy does not increase the temperature of the body, and therefore cannot be detected by the thermometer. The heat-energy is then in the condition of *stored* or *potential energy,* sometimes called *latent heat.* When the vapor condenses into a liquid, or the liquid freezes, *the stored heat-energy again becomes sensible as heat.*

In freezing, water gives out heat and raises the mean temperature of the atmosphere.

In melting, ice takes in heat and lowers the mean temperature of the atmosphere.

Water has a higher latent heat than any other common substance.

Stored Heat-Energy of Ice-Cold Water.—In order to heat a pound of water 1° Fahr. an amount of heat called *a heat-unit, or a pound degree* is required. Before one pound of ice at 32° Fahr. can melt and form one pound of water at 32° Fahr., *it must take in 142 heat units;* and yet a thermometer plunged in the water from melting ice will indicate the same temperature as when entirely surrounded by lumps of the unmelted material.

The great *latent heat of ice-cold water* has an important influence on the freezing of large bodies of water, since, after the surface-layers have reached the temperature of the freezing-point, they have still 142 *heat-units to lose* before they can solidify. Again, when ice reaches a temperature of 32° Fahr., it has still 142 *heat-units to absorb* before it can melt. Were it not for this fact destructive floods would often result from the rapid melting of the winter's accumulation of snow and ice.

Stored Heat-Energy of Water-Vapor.—Before one pound of water can pass off as vapor, it must take in sufficient heat to raise nearly 1000 pounds of water 1° Fahr. The vapor which then escapes is still at the same temperature as the water from which it came. *The 1000 heat-units, or pound-degrees of heat, have been rendered latent,* and have no influence on the thermometer.

When the vapor in the air is condensed as rain, snow, hail, fog, or cloud. the stored heat-energy again becomes sensible. Much of the vapor which is formed in the equatorial regions is carried by the winds to high northern latitudes, where, on condensing, it gives out its heat and moderates the intense cold which would otherwise exist.

152. Solvent Powers.—Water is one of the best solvents of all common substances. During the constant washings to which the continents are subjected by the rains, their surfaces are cleansed from decaying animal and vegetable matters, which are partly dissolved and carried by the rivers into the ocean. The atmospheric waters in the same way cleanse the air of many of its impurities.

153. Water is the Main Food of Animals and Plants.—By far the greater part of the bodies of animals and plants is composed of water. Without large quantities of water no vigorous life can be sustained in any locality.

Deserts are caused entirely by the absence of water.

CHAPTER II.

Drainage.

154. Drainage.—*The atmospheric waters,* or those which fall from the atmosphere as rain, hail, or snow, either sink through the porous strata and are drained under ground, or run directly off the surface. Thus result two kinds of drainage—*Subterranean* and *Surface.*

155. Subterranean Drainage.—The water which sinks through the porous strata continues descending until it meets impervious layers, when it either runs along their surface, bursting out as springs at some lower level, where the layers outcrop, or it collects in subterranean reservoirs. The origin of all springs is to be traced to subterranean drainage.

Underground streams sometimes attain considerable size. In portions of the Swiss Jura streams burst from the sides of hills in sufficient volume to turn the wheels of moderately large mills. In a few instances the subterranean stream can be navigated for considerable distances, as in the Mammoth Cave of Kentucky, or in the Grotto of Adelsberg, near Trieste.

156. Surface Drainage.—The water which is drained directly from the surface, either runs down the slopes in rivulets and rills, which, uniting with larger streams, are poured directly into the ocean, or it collects in the depressions of basin-shaped valleys, where, having no connection with the ocean, it can be discharged by evaporation only. Thus arise two kinds of surface drainage—*oceanic* and *inland.*

157. Springs are the outpourings of subterranean waters. The waters, having soaked through the porous strata, again emerge at the surface, either—

(1.) By running along an inclined, impervious layer of clay, hard rock, or other material until they emerge at some lower level, where the strata outcrop; or,

Fig. 57. Origin of Springs.

(2.) By being forced upward out of the reservoirs into which they have collected by the pressure of compressed gas, highly heated steam, or, more commonly, by the pressure of a communicating column of water.

It is in the first way that most of the springs of mountainous districts discharge their waters. The tilted and broken condition of the strata is such as to favor the escape along some of the many layers that crop out on the mountain-slopes. The springs of plains, which are at some distance from mountains, discharge their waters mainly by the methods mentioned under the second heading.

When a well is dug in most porous soils, the water from the porous strata on the sides runs in and partially fills the opening.

158. Classification of Springs.—Springs are most conveniently arranged in different classes according to peculiarities in the *size, shape, and depth of their reservoirs, and the nature of the mineral substances composing the strata over which the waters flow, or in which they collect.*

The Reservoirs of springs are the places where the waters that sink into the ground collect. Reservoirs are sometimes large subterranean basins, but more frequently are merely porous strata, such as beds of sand or gravel, which lie between impervious layers of clay or hard rock. The water collects in the spaces between the particles of sand or gravel.

159. Size of Reservoir.—When the reservoir is *large*, the spring is *constant;* when *small*, the spring is *temporary.*

Constant Springs are those which flow continually, and are but little affected in the volume of their discharge even by long-continued droughts.

Temporary Springs are those which flow only for a short time after wet weather, drying up on the appearance of even moderate droughts.

The quantity of water discharged by a spring depends on the size of the orifice or outlet tube, and the depth of the outlet below the surface of the water in the reservoir. The flow is proportional to the square root of the depth. That is to say, if with a given depth of orifice the velocity be one foot per second, in order to make the water escape with twice the velocity the depth must be increased fourfold. The actual velocity is somewhat less than this, being diminished by friction.

Since the volume discharged by some springs is very considerable, we must infer that their reservoirs are of great size. Many springs probably receive the drainage from hundreds of square miles of surface.

160. Shape of the Reservoir.—When the outlet tube of the reservoir is siphon-shaped, the discharge of the spring becomes *periodical.* The

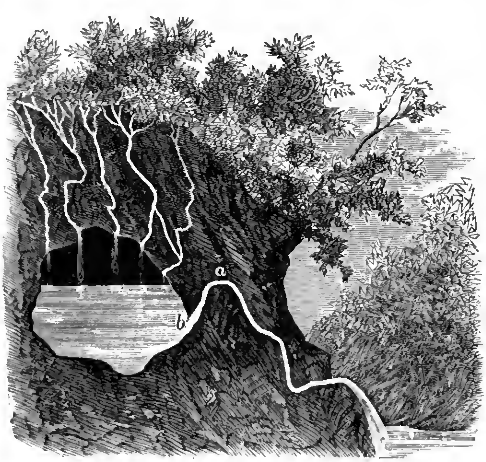


Fig. 58. A Periodical Spring.

spring continues to discharge its waters for a time, and then stops flowing, even during wet weather. After a certain interval it again discharges. The times during which the spring continues to discharge are always practically the same. Hence the spring is called a periodical spring.

The cause of periodical springs is due to the siphon-shape of the outlet tube. A siphon is a tube so bent as to have two vertical arms of unequal length. When filled, it will continue to discharge as long as its shorter arm is below the water and the longer arm free. If a large cavernous reservoir be in connection with the surface of the earth by a tube of this shape, it will begin to discharge its water when, by infiltration, the level reaches the highest bend of the tube, as at *a*, in Fig. 58, since the water will then drive out the air and fill the entire tube. The discharge will then continue until the water-level falls below the mouth of the tube, or at *b*, in the figure. The time of the discharge is always practically the same, since the same quantity is discharged each time under exactly similar conditions.

Springs are common on the shores of the ocean. Their waters are fresh because the outflow of the fresh water prevents the inflow of the salt water. This is the case even on coral islands, where the height of the land is but ten or twelve feet above the sea. A comparatively shallow well, on such islands, generally yields fresh water, derived, of course, from the rainfall.

161. Depth of Reservoir.—According to the distance the reservoir is situated below the surface of the earth, springs are divided into *Cold*, and *Hot or Thermal.*

Cold Springs are those whose temperature does not exceed 60° Fahr. Their waters are sometimes much colder than 60° Fahr.

Very cold springs owe their low temperatures to the sources whence they draw their supplies. In mountainous districts these can generally be traced to the melting of huge snow-fields, or masses of ice called glaciers. The temperature in such cases is often nearly that of ordinary ice-water.

The reservoirs of all springs the temperature of whose waters ranges from 50° to 60° are, in general, comparatively near the surface. They are colder than surface waters—

(1.) Because they are shielded from the sun;

(2.) Because evaporation occurs in their cavernous reservoirs.

The temperature of springs of this kind is, in general, but slightly affected by changes in the temperature of the outer air. Since the reservoirs of ordinary springs are shielded from the hot air in summer and from the cold air in winter, their waters are colder than river-water in summer, and warmer than river-water in winter. Their waters average, in their temperature, that of the strata over which they flow in their subterranean course.

The mean annual temperature of the strata over which the waters flow can, therefore, be ascertained by plunging a thermometer into the water as it comes out of the spring.

Hot or Thermal Springs range in temperature from 60° Fahr. to the boiling-point. In *geysers* the temperature of the water far down in the tube is considerably above the boiling-point at the surface.

Hot springs which occur in the neighborhood of active volcanoes *owe their high temperature to the vicinity of their reservoirs to beds of recently-ejected lava.*

Hot springs, however, are common in regions distant from volcanic disturbance. *In such cases their high temperature must be attributed to the distance of their reservoirs from the earth's surface, the heat being derived directly from the interior.*

In some cases the source of the heat is to be attributed to chemical action in neighboring strata.

Thermal springs, whose reservoirs are at comparatively moderate depths, may discharge their waters by ordinary hydrostatic pressure; but where, from the great depth of the reservoirs, this force would be insufficient, the waters are probably raised to the surface by the pressure of superheated steam or compressed gas.

Since the temperature rises 1° for about every 55 feet of descent, in cases where the increased temperature is due solely to depth, if the issuing waters have a temperature of 149° Fahr., the reservoirs must be about one mile below the surface, or fifty-five times the difference between 149° and 60°, the temperature of ordinary springs. In many cases the waters probably rise from profound depths as columns of steam, condensing in reservoirs that are less profound.

Source of Deep-seated Waters.—Deep-seated waters are probably derived by infiltration from the bed of the ocean. The natural porosity of large areas is greatly increased by the immense pressure of the water, which in the deep ocean is equal to thousands of pounds per square inch.

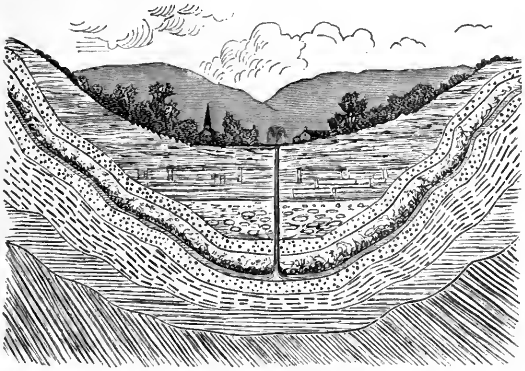


Fig. 59. Artesian Well.

162. Artesian Wells differ from ordinary wells in that their waters are discharged by natural pressure on their reservoirs, so that pumping is not necessary to raise the water. Such wells are therefore true springs.

The reservoirs are basin-shaped, and generally consist of several water-logged, porous strata, contained between two, curved, impervious strata. If the upper porous layer be pierced, the waters will flow out by reason of the pressure of the liquid in the higher parts. The reservoirs of many natural springs are of this kind, the upper impervious strata being broken in one or more places by some natural force.

Artesian wells have been sunk to great depths, and it is a significant fact that the temperature of the issuing waters is always proportional to the depth, showing a nearly constant increase of 1° above the temperature of ordinary springs—viz. about 60° Fahr.—for every 55 feet of descent. In the case of the artesian well of Grenelle, Paris, the successful boring of which was accomplished only after many years of the most discouraging labor, and which reached a depth of nearly 1800 feet, the temperature of the water was 82° Fahr. A well at Neusalzwerk, Prussia, has penetrated 2200 feet; its temperature is 91° Fahr.

163. Geysers are boiling springs which, at intervals more or less regular, shoot out huge columns of water with great violence. They are

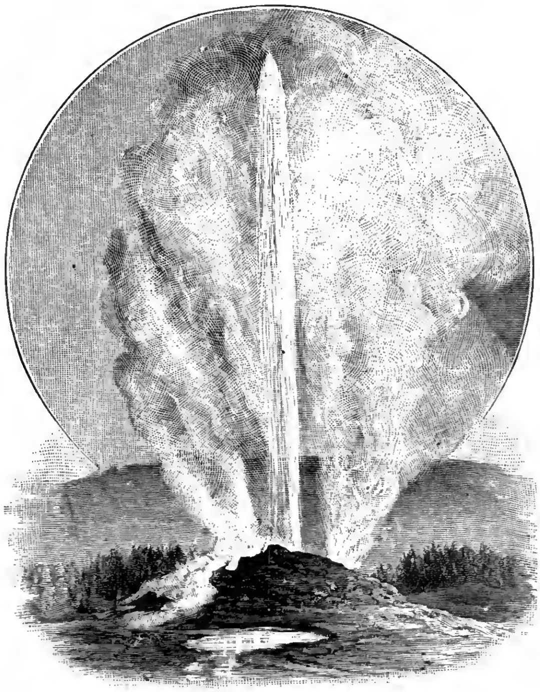


Fig. 60. Geyser in Eruption.

confined to the neighborhood of volcanic districts, and, by some, are classed with subordinate volcanic phenomena. The jets of water sometimes reach a height of more than two hundred feet.

The geyser issues from the summit of a conical hillock of silicious material deposited by the water. A broad, shallow basin generally surmounts the hillock and forms the mouth of a deep, funnel-shaped tube. The sides of both tube and basin are lined with a smooth incrustation of silica. In the Great Geyser of Iceland, the basin is 52 feet wide and the tube 75 feet deep.

Both the tube and basin are the work of the spring, being deposited from the silica contained in the highly heated waters. It is only when the tube has reached a certain depth that the spring becomes a true geyser. When the depth becomes too great the geyser eruptions cease, the waters forcing their way through the walls of the tube to some lower level. Hence, in all geyser regions, numerous deserted geyser-tubes, and simple thermal springs occur.

The waters of some geyser regions are calcareous. In this case the tube of the geyser is, of course, formed of limestone.

164. Bunsen's Theory of Geysers.—Bunsen explains the cause of geyser eruptions as follows: The heat of the volcanic strata, through which the geyser-tube extends, causes the water which fills it to become highly heated. The water at the bottom of the tube, having to sustain the pressure of that above it, gradually acquires a temperature far above the boiling-point at the surface. The temperature of the water in the tube will, therefore, decrease from the bottom to the surface.

If now, when the tube is filled, the water, near the middle, is brought to its boiling temperature, the steam thus formed momentarily lifts the water in the upper part of the tube, when the water in the lower part, released from its pressure, bursts into steam and forcibly ejects the contents of the tube.

Bunsen succeeded in lowering a thermometer into the tube of the Great Geyser in Iceland just before an eruption. At the depth of 72 feet he found the temperature of the water to be 261° Fahr., or 49° above the ordinary boiling-point.

165. Geyser Regions.—There are three extensive geyser regions:

(1.) *In Iceland*, in the south-western part of the island, where over one hundred occur in a limited area.

(2.) *In New Zealand*, about the centre of the northern island, where, near the active volcano Tongariro, over one thousand mud springs, hot springs, and geysers burst from the ground.

(3.) *In Yellowstone National Park*, in Wyoming, where numerous large geysers occur, mostly near the head-waters of the Madison and Yellowstone Rivers, at heights often as great as 8000 feet above the sea-level. Here the boiling-point of the water at the surface of the geyser, owing to the diminished atmospheric pressure, is as low as about 200° Fahr.

A small geyser region is found in California, near San Francisco.

166. Nature of the Mineral Substances forming the Reservoir.—The subterranean waters dissolve various mineral matters either from the strata over which they flow, or from their reservoirs; this is especially true of thermal springs, owing to the greater solvent powers of the heated waters.

The waters of mineral springs generally contain a number of mineral ingredients. Mineral springs are divided into various classes according to the predominating material.

(1.) **Calcareous Springs** are those whose waters contain lime in solution.

Thermal waters charged with carbonic acid usually contain large quantities of lime, which they have dissolved from subterranean strata. On reaching the surface the waters cool and part with some of their carbonic acid, and deposit layer after layer of hard limestone, called *travertine*. In this way immense quantities of limestone are brought to the surface from great depths, leaving huge subterranean caverns.

In portions of Tuscany, Italy, beds of travertine occur more than 250 feet thick.

(2.) **Silicious Springs** are those whose waters contain silicon.

(3.) **Sulphurous Waters** are those whose waters contain sulphuretted hydrogen and various metallic sulphides or sulphates.

Sulphurous springs are found in Baden, near Vienna, and in Virginia.

(4.) **Chalybeate Waters** are those whose waters contain iron.

(5.) **Brines**, or those whose waters contain common salt.

The springs of Halle, in the Alps of Salzburg, yield 15,000 tons of salt annually. The artesian well of Neusalzwerk, Prussia, yields about 28,000 tons annually. In the United States the springs of Salina and Syracuse are among the most important. The water in the springs of Salina is ten times salter than ocean-water. The salt is obtained from these springs by the evaporation of the water.

(6.) **Acidulous Springs** are those whose waters contain large quantities of carbonic acid gas, as the Seltzer springs in Germany, and those of Vichy in France.

167. Petroleum and Bituminous Springs.—Besides the springs above mentioned, there are two others, closely connected, but which can scarcely be included in any of the above classes. These are *petroleum* and *bituminous springs*.

Petroleum Springs are those containing rock- or coal-oil. They rise from large reservoirs containing oil instead of water. The oil is derived from the slow decomposition, in the presence of heat, of various animal and vegetable matters which are found in the strata of nearly all the geological formations. The reservoirs are of the same nature as those of artesian wells, the oil being obtained by boring.

Petroleum springs are numerous. The most extensive regions in the world are found in the great oil districts of Western Pennsylvania and the neighboring States.

Bituminous Springs, or those from which pitch or bitumen issue. Their origin is the same as that of oil springs, the decomposition, however, occurring in a somewhat different way. The famous pitch lake on the island of Trinidad, north-east of South America, probably owes its origin to the large quantities of trees and other vegetable matters, which have been rolled down the Orinoco and buried in the delta formation on the eastern shores of the island.

CHAPTER III.

Rivers.

168. Definitions.—The water that issues from the ground as springs, that is derived from the melting of ice or snow, or that drains directly from the surface after rainfall, runs down the slopes of the land and collects in the depressions formed by the intersection of the slopes, forming rills or rivulets, which at last combine in larger streams called *rivers.*

The *source* of a river is the place where it rises; the *mouth,* the place where it empties; the *channel,* the depression through which it flows. Rivers generally rise in *mountains,* where the rainfall is greater than elsewhere, and where vast beds of snow and ice occur.

In reality, all rivers have three mouths, or places where they discharge their waters:

(1.) Where the river empties directly into some other body of water;

(2.) Where the river empties by evaporation into the air; that is, its entire upper surface;

(3.) Where the river empties into the earth through the porous strata of its bed or channel.

Since the downward motion of a river is caused by the inclination of its channel from the *source* to the *mouth,* a correct idea of the general inclination of any country can be obtained by a careful study of a map in which the directions of the rivers are represented. In studying the various river-systems the student should endeavor to obtain in this way clear ideas *of the general directions of the continental slopes.*

The River-System is the main stream, with all its tributaries and branches.

The Basin is the entire area of land which drains into the river-system.

The Water-shed is the ridge or elevation which separates two opposite slopes. The streams flow in opposite directions from the water-shed.

The Velocity of a river depends on the inclination or pitch of the channel and the volume or depth of the water.

169. River-Courses.—The river-channel, from its source to its mouth, is, for ease of description, conveniently divided into three parts or courses: the *upper, middle,* and *lower.*

The Upper Course of a river is that part which is situated in the mountainous or hilly country near its source. In this course the river has a great velocity, and its channel is characterized by sharp, sudden turns, alternating with long, straight courses. In the upper course *erosion* occurs almost entirely along the bottom of the channel, so that the river runs between steep, and sometimes almost vertical, banks. In this way *river-valleys* are formed, generally with narrow and overhanging, precipitous sides. In the upper and middle courses *rapids* and *waterfalls* occur.

Rapids and Waterfalls.—During the erosion of the channel, where harder rocks occur in the bed of the stream, the softer strata, *immediately adjoining them down stream,* are rapidly worn away, and the obstruction becomes at last the head of a waterfall. The height grows rapidly from the increased force of the falling water, and continues until stopped by some similar obstruction below.

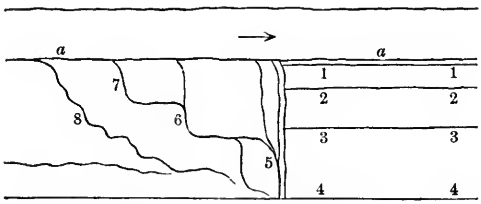


Fig. 61. Erosion of Waterfall.

Thus, suppose *a a,* Fig. 61, is the bed of a river, the direction of flow of which is shown by the arrow. The softer rock being worn away more rapidly, the bed reaches the level 1, 1. A fall, and consequent increase in the velocity of the river, soon causes the level of the bed to reach 2, 2, 3, 3, and 4, 4, successively. At the same time the falling water eats away the vertical wall of the precipice, causing *the waterfall to move up stream.* The water then cuts the precipice away in steps, as shown at 5, 6, 7, thus changing the fall into cascades. These are finally worn away, as shown at 8, changing the cascades to rapids, when, finally, the fall disappears entirely, or the erosion of the hard rock is completed.

When the water falls perpendicularly—that is, when it does not slip or slide—it forms a *waterfall* or *cataract;* in all other cases of swift descent it forms *rapids.*

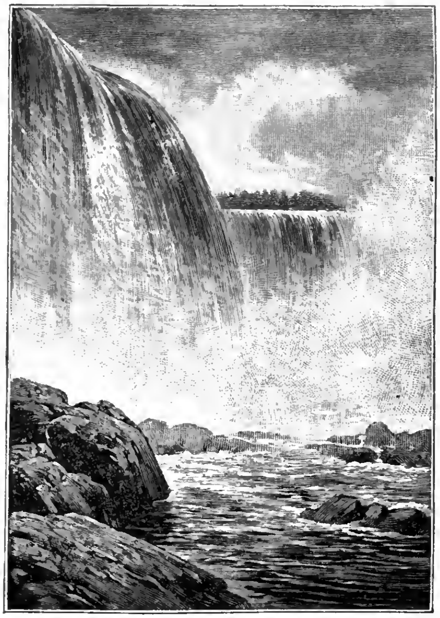


Fig. 62. The Falls of Niagara.

The grandest falls in the world are those of the Niagara, 160 feet high. Though greatly inferior to many others in height, yet their volume of water is so great that they surpass all others in grandeur. The Victoria Falls of the Zambezi in Africa nearly equal in volume those of the Niagara. Their height is 360 feet.

The highest falls in the world are those of the Yosemite, in California. Two projecting ledges break the sheet into three falls, whose total height exceeds 2000 feet. One of the highest falls in Europe is the Staubbach or Dust-brook, in the valley of the Lauterbrünnen in Switzerland. The water makes one sheer fall of 959 feet, and is lost in a sheet of mist before it reaches the ground.

The Middle Course extends from where the river emerges from the mountainous or hilly districts to the low plains near the mouth. The descent is comparatively slight, and the velocity small. The erosion of the *bottom* of the channel is insignificant, but *at the sides*, especially during freshets, the river undermines its banks and thus widens its valley. Here the river is divided into two distinct portions: the *channel proper* and the *alluvial flats or flood-grounds.*

The Lower Course extends from the middle course to the mouth. The fall is slight, and the velocity small.

170. Changes in River-courses.—During floods, when the velocity and eroding power are greatly increased, extensive changes often occur in river-courses. After the floods have subsided the water is found running through new channels, its old ones being either completely filled with deposits of mud, or occupied by slender streams. Along the Mississippi these partially deserted channels are called *bayous*, and, in places, widen out into large lakes. (See Fig. 63.) The Red River appears to have formerly emptied into the Mexican Gulf through a separate channel. In the basins of the Amazon, the Ganges, and the Po, the old deserted channels are numerous on both banks of the streams.

171. River Mouths.—A wide, open river-mouth is called an *Estuary;* the accumulation of mud or sand which occurs in the mouths of certain rivers is called a *Delta.*

172. Inundations.—During certain seasons of the year, the amount of water drained into the river-channel is greater than it can discharge; it then overflows its banks and inundates the surrounding country.

Inundations of rivers are caused—

(1.) By excessive rainfall;

(2.) By periodical rains;

(3.) By the melting of ice and snow.

In the tropics, where the rainfall is more or less periodical, the inundations of the rivers are also periodical. The melting of the ice and snow, which occurs regularly at the beginning of the warm weather, also causes periodical inundations. The Nile rises annually on account of the periodical rainfall of its upper sources; the Mississippi semi-annually, once from the melting of snow, and once from the winter rainfall.

When both the area of the river-basin and the rainfall in inches are known, experience permits of a calculation, by means of which the probable time and extent of rise of water in a river can be approximately predicted. In times of heavy rainfall, the Weather Bureau of the United States is enabled to predict the probable rise of the important rivers.

Influence of the Destruction of the Forests on Inundations.—When the forests are removed from a large portion of a river-basin, the rains are no longer absorbed quietly by the ground, but drain rapidly off its surface into the river-channels, and thus in a short time the entire precipitation is poured into the main channel, causing an overflow. It is from this cause that the disastrous effects of otherwise harmless storms are produced. The inundations are most intensified by this cause in the early spring, when the ice and snow begin to melt. The destructive effects of the floods are increased by masses of floating ice, which, becoming gorged in shallow places in the stream, back up the waters above. The increased frequency of inundations in the United States is, to a great extent, to be attributed to the rapid destruction of the forests.

173. The Quantity of Water Discharged by a River depends principally—

(1.) On the *size* of the basin;

(2.) On the *amount* of the rainfall.

The quantity of water in a river also depends—

(1.) On the *climate* of the basin, a dry, hot air diminishing the quantity by evaporation;

(2.) On the *physical features of the basin,* whether wooded or open;

(3.) On the *nature of the bed or channel*, whether leaky or not.

It will be noticed that these three circumstances are connected with the two additional river-mouths already alluded to: the air-surface of the river, and the channel-surface.

Keith Johnston estimates the daily discharge of all the rivers of the world at 229,000,000,000 cubic yards, or over 2,620,000 cubic yards per second.

CHAPTER IV.

Transporting Power of Rivers.

174. Silt or Detritus.—Rivers are ceaselessly at work carrying the eroded materials, called *silt* or *detritus*, from their upper to their lower courses. Valleys are thus formed, miles in width and thousands of feet in depth, and lofty mountains greatly reduced in height.

The amount of silt transported by rivers is almost incredible. According to the careful estimates of Humphreys and Abbot, the silt brought down every year by the Mississippi and thrown into the Mexican Gulf, if collected in one place, would cover a field one square mile in area to the depth of 268 feet. According to Lyell, the deposits, in the Bay of Bengal, of the Ganges and the Brahmapootra, are nearly as great.

The rivers are carrying the mountains seaward, and the continents are thus decreasing in mean height and increasing in mean breadth.

175. Deposition of Silt.—Since the silt or eroded mineral matter is heavier than water, it will *settle* in all parts of the river-course. It will, however, *remain* in those places only where the velocity of the river is comparatively small. These places are as follows:

(1.) In the channel of the river;

(2.) On the banks, over the alluvial flats or flood-grounds;

(3.) At the mouth;

(4.) Along the coast near the mouth.

176. In the Channel.—In rivers that traverse great plains, the inclination near the mouth is slight, and the diminished velocity allows the material to accumulate in the channel, thus raising the general level of the stream. When the rivers traverse settled districts, the inhabitants are compelled to erect huge river-walls to prevent the flooding of the adjacent lands; and, in some places, the channel has been filled to such an extent that the ordinary level of the river is higher than that of the plains along its banks.

The levees or banks of the Mississippi are of this nature. On the level plain of Lombardy the surface of the Po, in some places, is higher than the tops of the neighboring houses. When floods occur in such districts, the breaking of a levee or river-wall is generally attended by much loss.

177. Rafts.—Drift timber, thrown into the stream by the undermining of the banks, is common in rivers that traverse wooded districts. Portions of such timber, becoming imbedded in shallow parts of the channel, form obstructions which prevent the passage of subsequent masses. The impediment so formed checks the velocity of the stream, and mud deposits occur between the trees. Such accumulations are called *rafts*. The raft of the Red River, previous to its removal, was thirteen miles in length. A large raft exists near the mouth of the Mackenzie River in British America.

178. On the Alluvial Flats or Flood-grounds.—The low flat plains on the sides of the river, which are formed by the erosion of the banks in the middle and lower courses, are covered by the water when the river overflows its banks. In the shallow water over these parts the velocity of the water is slight, and the silt is deposited, thus forming rich alluvial plains.

In large rivers the flood-grounds often attain considerable size. In the Mississippi at Vicksburg the width of the alluvial plain is over 60 miles.

In the lower courses of a river, the velocity being small, comparatively slight obstacles suffice to turn the waters from their course. The river-channel is therefore characterized by wide bends

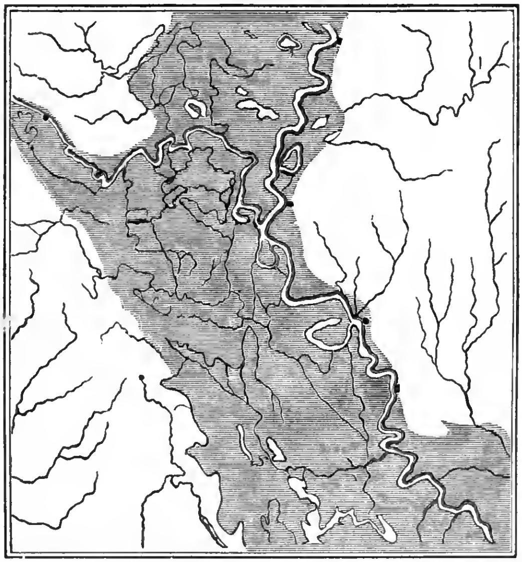


Fig. 63. Alluvial Flats of the Mississippi.
(Showing deserted courses and fluviatile islands and lakes.)

or curves. At the bend of a river the main current is directed against one of the banks, where rapid erosion takes place, the eroded material accumulating lower down the river, in the bed of the stream, where the velocity is small. The river is thus continually damming up portions of its old channel and cutting new ones.

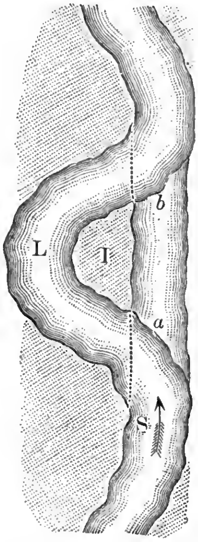


Fig. 64. Formation of Fluviatile Islands and Lakes.

The rapid excavation of these portions of the alluvial plain is favored by the loose materials which compose it. Sometimes the river cuts a new channel across the narrow neck of a bend, part of its waters running through the old channel and part through the new. In this way *fluviatile islands* are formed. One of the channels is sometimes separated from the other by a deposition of mud or sand. The water fills the old channel by soaking through the soil, and thus *fluviatile lakes* are formed. Numerous fluviatile lakes occur near the banks of the Lower Mississippi and the Red River.

Thus, suppose the river flows in the direction of the arrow at S, Fig. 64, and its channel has the bends shown. A new channel may be formed at *a*, *b*, the river either flowing through both channels, thus converting the neck of land I, into a fluviatile island, or the old channel may fill up and form a fluviatile lake, L, by bars forming in the old channel at *a* and *b*.

179. At the Mouth.—Delta Formations.—In sheltered parts of the ocean, where the tides are weak and the ocean-currents feeble, or in inland seas and lakes, where they are entirely absent, the eroded material accumulates at the mouth of the river in large, triangular-shaped deposits, called *deltas*, from their resemblance to the Greek letter (Δ) of that name.

The Delta of the Mississippi is the largest in the Western Continent. Its entire area is about 12,300 square miles, though but two-thirds of it are permanently above the water, the remainder being a sea-marsh. It begins a little below the mouth of the Red River. The stream cuts through the delta in one main channel, but near the extreme end of the delta forms several mouths. On all sides of the main stream, numerous smaller streams force their way into the Gulf through the soft material.

The Delta of the Nile, at its outlet into the Mediterranean, occupies an area of nearly 9000 square miles. A large portion of the sediment of the river is deposited over the flood-grounds during inundations. The fertility of the land is largely dependent on these deposits.

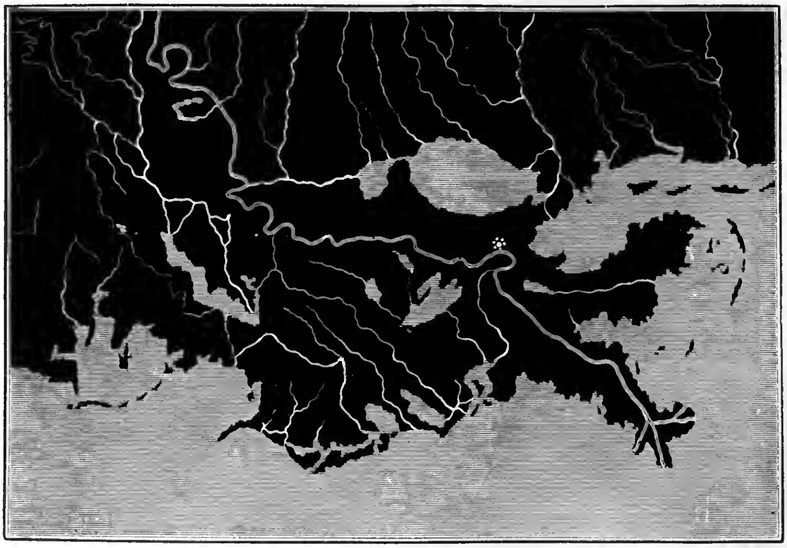


Fig. 65. Delta of the Mississippi. (After Dana.)

The Delta of the Ganges and the Brahmapootra, in the Bay of Bengal, is considerably larger than the Delta of the Nile. Between the Hoogly and the main branch of the Ganges, numerous streams force their way between countless islands, called the Sunderbunds, inhabited by tigers and crocodiles. *The Po, the Rhone, the Rhine, and the Danube in Europe, the Tigris, the Euphrates, the Yang-tse-Kiang and Hoang-Ho in Asia, and the Senegal and the Zambezi in Africa,* have extensive deltas.

180. Along the Coast, near the Mouth.—Fluvio-Marine Formations are deposits of silt that form along the coast near and opposite the mouths of rivers, under the combined action of the river-current and the tides of the ocean. A sand-bar is formed at some little distance from the mouth of the river, where the outflowing river-current

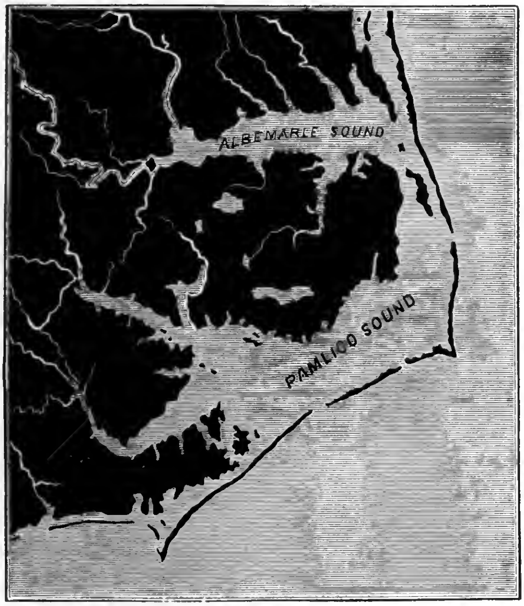


Fig. 66. Fluvio-Marine Formations.

and the inflowing tide neutralize each other. The impediment so formed permits of the rapid deposition of silt, which fills up the portions of the ocean so shut off, and converts them into shallow bodies of water called *sounds*. These sounds, by gradual rising of the land, are afterward converted into river-swamps. According to Dana, the eastern and southern coasts of the United States, from Virginia to Texas, are an almost continuous fluvio-marine formation. *Albemarle and Pamlico Sounds and the Great Dismal, Alligator, and Okefinoke Swamps* are but different stages in the formation of these deposits.

CHAPTER V.

Drainage Systems.

181. Continental Drainage is dependent on the position of the mountain-systems and the direction of their slopes. The mountain-ridges or peaks, or the high plateaus, form the water-sheds. In some cases, from a single peak or plateau, the water drains into distinct river-systems, emptying into different oceans.

182. North America.—The central plain of North America is drained by four large river-systems: the Mackenzie into the Arctic Ocean; the Saskatchewan and the Nelson into Hudson Bay; the St. Lawrence into the Gulf of St. Lawrence; and the Mississippi into the Gulf of Mexico. The basin of the Mississippi occupies the long slopes of the Rocky Mountains and the Appalachians. The Missouri and the Ohio are the principal tributaries of the Mississippi.

Numerous streams descend the eastern slopes of the Appalachian system into the Atlantic.

Owing to the position of the predominant system, the streams which empty into the Pacific are comparatively small. The principal are the *Yukon*, the *Columbia*, and the *Colorado*.

There are several remarkable isolated water-sheds or drainage-centres in North America. These are—

(1.) In the central part of the Rocky Mountain system, where the land drains in different directions into the systems of the Mississippi, the Columbia, and the Colorado Rivers.

(2.) In the northern part of the Rocky Mountains, where the drainage is received by the systems of the Yukon, the Mackenzie, and the Saskatchewan Rivers.

183. South America resembles North America in its drainage systems. The long, gentle slopes of the Andes, and those of the systems of Brazil and of Guiana, are occupied at their intersections by the three great river-systems of the continent: that of the *Orinoco*, in the north; that of the *Amazon*, near the centre; and that of the *La Plata*, in the south. Nearly the entire continent is drained by these rivers and their tributaries into the basin of the Atlantic.

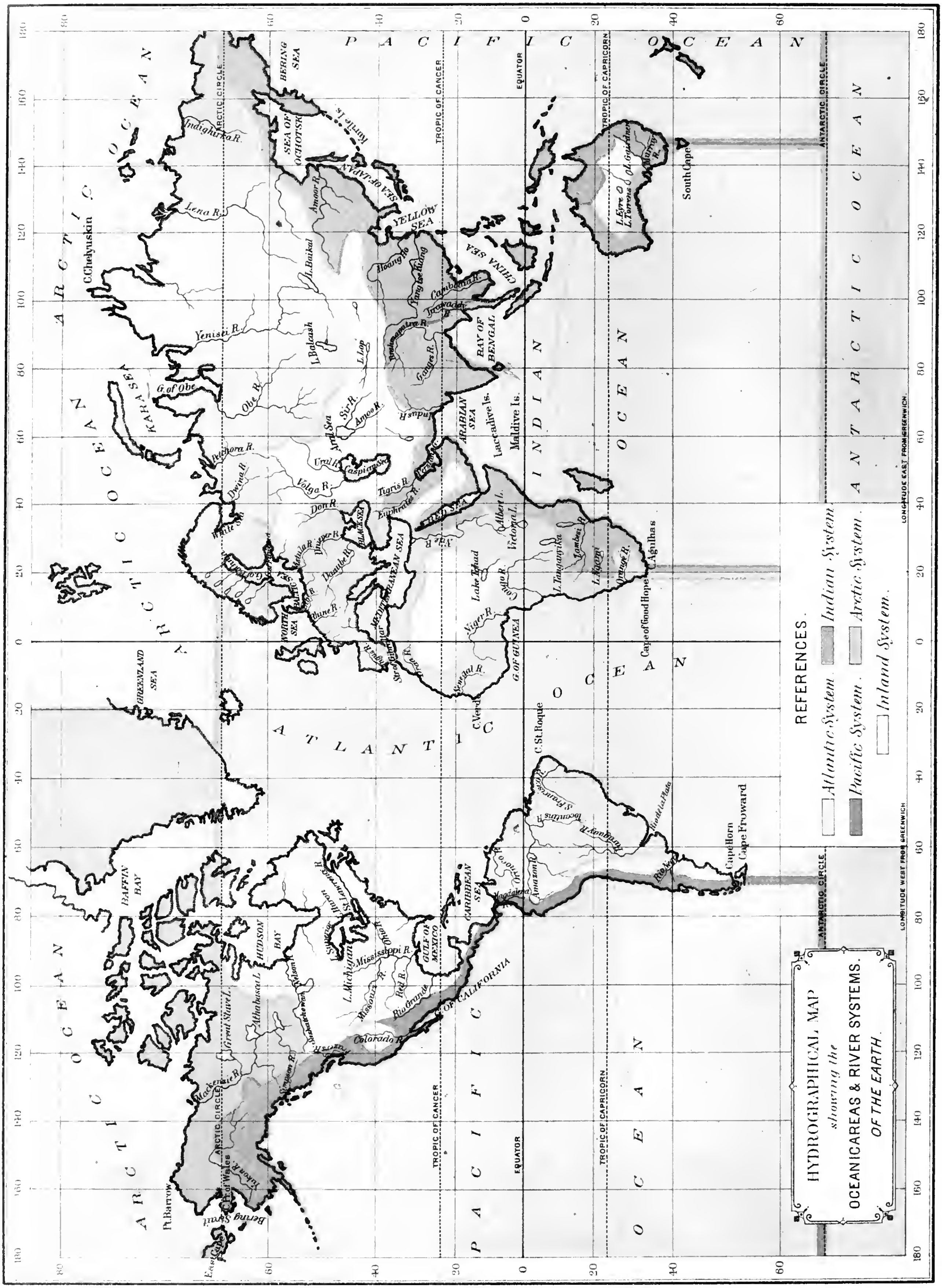
The Pacific receives no considerable streams. Only impetuous mountain-torrents are found.

The Magdalena, which drains north, corresponds to the Mackenzie; the Orinoco and the Amazon, which drain east, to the Nelson and the St. Lawrence; and the La Platte, which drains south, to the Mississippi.

184. Europe forms an exception to the other continents as regards its drainage. Though some of its large rivers rise in its predominant mountain-system, yet the majority rise in the inconsiderable elevations of the Valdai Hills. The Alps are drained by four large rivers—the *Rhone*, the *Rhine*, the *Danube*, and the *Po*. These all have large deltas.

Although in this part of the continent the frequent intersection of the two lines of trend produces numerous basin-shaped valleys, yet, owing to breaks in the enclosing mountains, none of any size have an inland drainage, but discharge their waters through numerous tributaries into one or another of the principal river-systems.

The Great Low Plain of Europe is drained toward the *north and west* by the *Petchora* and *Dwina* into the Arctic; by the *Duna*, the *Niemen*, the *Vistula*, and the *Oder* into the Baltic;


HYDROGRAPHICAL MAP
showing the
OCEANICAREAS & RIVER SYSTEMS.
OF THE EARTH.
REFERENCES.
Atlantic System.
Indian System.
Pacific System.
Arctic System.
Inland System.
ARCTIC OCEAN
PACIFIC OCEAN
ATLANTIC OCEAN
INDIAN OCEAN
ANTARCTIC OCEAN
ARCTIC CIRCLE
TROPIC OF CANCER
EQUATOR
TROPIC OF CAPRICORN
ANTARCTIC CIRCLE
LONGITUDE WEST FROM GREENWICH
LONGITUDE EAST FROM GREENWICH
BAFFIN BAY
HUDSON BAY
GULF OF MEXICO
CARIBBEAN SEA
G. OF CALIFORNIA
GREENLAND SEA
NORTH SEA
BLACK SEA
RED SEA
ARABIAN SEA
BAY OF BENGAL
CHINA SEA
YELLOW SEA
SEA OF JAPAN
SEA OF OCHOTSK
BERING SEA
KARA SEA
G. OF GUINEA
Bering Strait
Pt. Barrow
Cape Horn
Cape Froward
C. St. Roque
C. Verde
Cape of Good Hope
C. Agulhas
South Cape
C. Chelyuskin
Yenisei R.
Lena R.
Obe R.
Amoor R.
Mississippi R.
Missouri R.
Amazon R.
Niger R.
Congo R.
Nile R.
Ganges R.
Indus R.
Volga R.
Danube R.

and by the *Elbe* and the *Weser* into the North Sea. It is drained toward the *south and east* by the *Ural* and the *Volga* into the inland basin of the Caspian; and by the *Don*, the *Dnieper*, and the *Dniester* into the Sea of Azov and the Black Sea.

All the peninsulas have streams traversing them. The *Seine*, the *Loire*, and the *Garonne* from France, and the *Douro*, the *Tagus*, and the *Gaudiana* from Spain and Portugal, empty into the Atlantic. The *Ebro* from Spain, and the *Po* from Italy, empty into the Mediterranean.

185. Asia possesses the most extensive inland drainage of all the continents. The plateaus are surrounded by lofty mountains containing but comparatively few breaks, and their waters, therefore, can find no passage to the sea. The outer slopes, however, are drained by some of the largest rivers in the world.

The Great Northern Plain drains into the Arctic, mainly through the *Lena*, the *Yenisei*, and the *Obe*.

The Eastern Slopes drain into the Pacific through the *Amoor*, the *Hoang-Ho*, the *Yang-tse-Kiang*, and the *Cambodia*.

The Southern Slopes drain into the Indian Ocean through the *Irrawaddy*, the *Brahmapootra*, the *Ganges*, the *Indus*, the *Tigris*, and the *Euphrates*.

The principal drainage-centre in Asia is the Plateau of Thibet, from which descend the Hoang-Ho, the Yang-tse-Kiang, the Cambodia, the Irrawaddy, the Ganges, the Brahmapootra, and the Indus.

186. Africa, being low in the interior, with high mountain-walls on her borders, is characterized, like the Americas, by the union of her smaller river-systems into a few large streams, which drain nearly the entire continent. These embrace the *Nile*, emptying into the Mediterranean; the *Zambezi*, into the Indian Ocean; and the *Orange*, the *Congo*, the *Niger*, and the *Senegal*, into the Atlantic.

187. Australia.—The *Murray*, which drains the south-eastern part of the continent into the Indian Ocean, is the only considerable stream.

188. Principal Oceanic Systems.—A careful study of the river-basins of the different oceans discloses the following fact:

The Atlantic and Arctic Oceans receive the waters of nearly all the large river-systems of the world.

The cause of this is as follows: The predominant systems being situated nearest the deepest ocean, the long, gentle slopes descend toward the smaller, shallower oceans (the Atlantic and the Arctic), which thus receive the greatest drainage.

For details of the various river-systems—such as the length, area of basin, etc.—see Table, page 170.

CHAPTER VI.

Lakes.

189. Lakes are bodies of water accumulated in depressions of the surface of the land.

They are connected either with the systems of *oceanic* or of *inland drainage*. The waters of lakes draining into the ocean are fresh; those having no connection with the ocean are salt.

Depth.—From their mode of formation lakes which occur in mountainous districts are, as a class, deeper than those found on the great low plains, since the former occupy the basins of narrow but deep valleys, and the latter the depressions of the gentle undulations of the plain.

In mountainous districts the depths of the depressions are sometimes so great that the bottom of the lake is considerably below the sea-level. *Lake Maggiore* in the Swiss Alps extends about 2000 feet below the level of the sea.

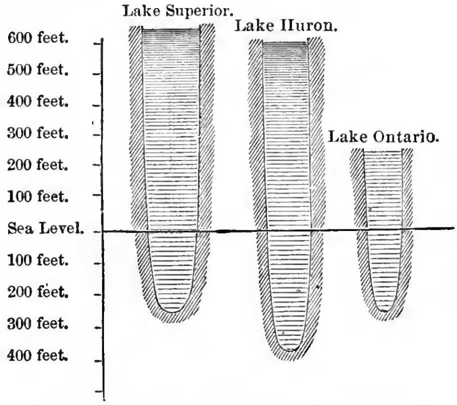


Fig. 67. Elevations and Depressions of Lakes.

One of the most remarkable series of depressions in the general land-surface of the world is that occupied by the waters of Lakes Superior, Michigan, Huron, Erie, and Ontario. Superior and Huron, though some 600 feet above the level of the ocean, reach, in their greatest depths, far below its surface; the former being 270 feet, and the latter about 400 feet, below the general level of the Atlantic.

When a lake is connected with a river-system, the place where the principal stream enters is called the *head* of the lake; the place where it empties is called the *foot* of the lake.

190. Geographical Distribution.—The large lake-regions of the world are almost entirely confined to the northern continents.

191. Oceanic Drainage Systems.—North America contains the most extensive lake-system in the world. The lake-region surrounds Hudson Bay, and drains into the Arctic through the Mackenzie; into Hudson Bay through the Saskatchewan; or into the Atlantic through the St. Lawrence. To it belong the Great Lakes—Superior, Michigan, Huron, Erie, and Ontario—

Fig. 68. View on Lake George, N. Y.

embracing a combined area of nearly 100,000 square miles—and the numerous lakes of British America.

Athabasca, Great Slave, and Great Bear Lakes drain into the Arctic through the Mackenzie; Lake Winnepeg, into Hudson Bay through the Nelson; and the Great Lakes, into the Atlantic through the St. Lawrence.

Europe contains two extensive systems of fresh-water lakes. The larger region is in *Low Europe*, and surrounds the Baltic Sea and its branches; to it belong Lakes *Ladoga* and *Onega* in Russia, *Wener* and *Wetter* in Sweden, with numerous smaller lakes. The smaller region is found in the Alps in *High Europe*.

Africa contains an extensive system of lakes west of the predominant system. Victoria and Albert Nyanzas, which drain into the Nile, Lake Tanganyika, which drains into the Livingstone or the Congo, and Lake Nyassa, which drains into the Zambezi, are the principal lakes.

The remaining continents contain but few large fresh-water lakes. In *South America* we find Lake Maracaybo, with brackish water from its vicinity to the sea; and in *Asia*, Lake Baikal.

192. The Inland Drainage Systems are intimately connected with that of *inland rivers*. The term *Steppe Lakes* and *Rivers* is generally applied to those which have no outlet to the ocean.

Cause of the Saltness of Inland Waters.—All river-water contains a small quantity of common salt and other saline substances. Since lakes which have no outlet, or, as they are generally called, *inland lakes*, lose their waters by evaporation only, the saline ingredients must be continually increasing in quantity; the water of such lakes is therefore generally salt.

The Dead Sea in Syria is remarkable for the quantity of its saline ingredients. In every one hundred pounds of its waters there are over twenty-six pounds, or more than one-fourth, of various saline ingredients.

North America.—The largest inland drainage-system is in the *Great Basin*, containing *Great Salt, Walker, Pyramid, and Owen Lakes.*

South America.—The largest region of inland drainage includes the plateau of Bolivia, containing Lake Titicaca. The waters of this lake are *fresh*, but have no outlet to the sea, the river forming the outlet being lost in a salty, sandy plain.

Europe and Asia contain a vast region of inland drainage extending from the Valdai Hills eastward to the Great Kinghan Mountains, embracing most of the Asiatic plateaus.

The region contains *Lake Elton* in Russia, and the *Caspian* and *Aral Seas*. The combined area of the last two is 175,000 square miles. They receive the waters of the *Volga*, the *Ural*, the *Sir*, and the *Amoo*, all large streams. Numerous lakes occur on the plateaus. *Lake Lop*, in the depression north of Thibet, receives the *Tarim*, and Lake Hamoon, on the Iranian plateau, the Helmund River.

Africa contains *Lake Tchad* in the Soudan, receiving the *Komadagu* and the *Shirwa*, and *Lake Ngami* in Southern Africa.

Australia contains Lakes *Eyre, Torrens, Gairdner*, and *Amadeo* near the southern coast.

193. Utility of Lakes.—By offering extended basins into which the rivers, when swollen, can disgorge themselves, lakes greatly diminish the destructive effects of inundations, often checking them entirely. They afford extended surfaces for evaporation, and, collecting the finer sediment of the rivers when deserted by their waters, form fertile plains.

SYLLABUS.

Water is formed by the union of oxygen and hydrogen.

The waters of the earth may be divided into two classes—the continental and the oceanic.

Water is a solid at and below 32° Fahr., a liquid from 32° to 212°, and a vapor above 212°. It passes off as vapor, however, at all temperatures.

A pint of water is heaviest at the temperature of 39.2° Fahr. Hence in deep lakes, covered with ice, the lower layers of water are 7.2° Fahr. above the freezing-point.

Large bodies of water moderate the extremes of temperature, because water takes in more heat while warming and gives out more on cooling than any other common substance.

During the freezing of a body of water, or the condensation of a mass of vapor, considerable stored heat-energy appears, or latent heat becomes sensible and warms the surrounding air.

After a body of water has been cooled to the temperature of 32° Fahr., it has still 142 heat-units, or pound-degrees, to lose before it can turn into ice.

After a body of ice has been warmed to the temperature of 32° Fahr., it has still 142 heat-units, or pound-degrees, of heat to gain before it can turn into water.

Therefore, both freezing and melting are gradual processes.

The rains cleanse the surface of the earth and purify the atmosphere.

Water is necessary for the existence of life. It forms the main food of both animals and plants.

The atmospheric waters are drained into the ocean either by surface or subterranean drainage.

Springs are the outpourings of the subterranean waters.

Springs may be classified according to peculiarities in the size, shape, and depth of their reservoirs, and the nature of the mineral substances composing the strata over which the waters flow or in which they collect.

According to the size of their reservoirs, springs are either *constant* or *temporary*.

If their reservoirs have siphon-shaped outlet tubes, their discharges are *periodical*.

When their reservoirs are superficial, springs are *cold;* when deep-seated, they are *hot* or *thermal*.

Springs whose waters are moderately cold have their reservoirs near the surface. Their lower temperature is due to their waters being shielded from the sun.

Springs with very cold waters have their sources in the melting of large masses of ice or snow.

Hot or thermal springs owe their high temperature to the heat they receive from the interior of the earth.

Geysers are boiling springs, which, at irregular intervals, shoot out huge columns of water with great violence.

The most extensive geyser regions are those of Iceland, New Zealand, and Wyoming.

Calcareous springs contain lime; silicious, silex; sulphurous, sulphuretted hydrogen and metallic sulphides or sulphates; chalybeate, iron; brines, common salt; acidulous, carbonic acid; petroleum, coal oil; bituminous, pitch.

Rivers are fed both by surface and subterranean drainage.

The main stream with all its tributaries and branches is called the river-system. The territory drained into the river-system is called the river-basin. The ridge or elevation separating opposite slopes is called the water-shed.

In the upper courses of rivers erosion occurs mainly on the *bottom* of the channel; in the lower courses, at the *sides*.

In the lower courses of rivers extensive flats or plains are found. They are caused by the erosion of the banks and the subsequent deposition of fine mud during inundations.

Rivers are constantly at work carrying the mountains toward the sea. Through their agency the mean height of the continents is decreasing, and their mean breadth increasing.

The eroded material, or silt, may accumulate—1. In the channel of the river; 2. Along the banks, on the alluvial flats or flood-grounds; 3. At the river's mouth; and 4. Along the coast, near the mouth.

The accumulations in the channel of the lower Mississippi have so raised the bed of the stream as to necessitate the erection of levees or embankments along the sides.

Where the tides are weak and the ocean currents absent or feeble, the eroded material, or silt, accumulates at the mouths of rivers in masses termed *deltas*.

The Alps are drained by the Rhine, the Rhone, the Po, and the Danube; these rivers have extensive delta-formations.

The plateau of Thibet is drained by the Hoang-Ho, the Yang-tse-Kiang, the Ganges, the Brahmapootra, and the Indus; all these rivers have extensive delta-formations.

Among other extensive deltas are those of the Mississippi, which drains the long slopes of the Pacific and Appalachian mountain-systems; the Nile, the Tigris, the Euphrates, and the Zambezi.

Fluvio-marine formations occur along the coasts; they are caused by the combined action of the *river* and *tides*.

The destruction of forests, by increasing the rapidity of drainage, increases the violence of floods. Lakes along the river-courses decrease their violence, by allowing the torrents to discharge their waters.

The direction of the drainage of a country is dependent on the direction of its slopes.

The central plain of North America is drained north into the Arctic Ocean through the Mackenzie; east into the Atlantic through the Nelson and the St. Lawrence; and south into the Gulf of Mexico through the Mississippi.

The central plain of South America is drained north into the Caribbean Sea through the Magdalena, east, into the Atlantic through the Orinoco and the Amazon, and south, into the Atlantic through the Rio de la Plata.

The rivers draining the great low plain of Europe rise either in the Valdai Hills or on the northern slopes of the predominant system.

Asia possesses the most extended system of inland drainage of the continents. Extended systems are also found in North America and Europe.

The Atlantic and the Arctic Oceans drain about three-fourths of the continental waters.

The largest systems of fresh-water lakes occur in North America and Europe.

The Great Lakes of North America occupy remarkable depressions in the continent. The beds of some of them are several hundred feet below the level of the sea.

Lakes without an outlet are salt, because the waters they receive contain small quantities of saline ingredients, while the waters they lose contain none.

REVIEW QUESTIONS.

What is the composition of water?

Enumerate the physical properties which enable water to play so important a part in the economy of the earth.

What effect has the temperature of the maximum density of water on the freezing of large bodies of fresh water? Why?

How do large bodies of water moderate the extremes of heat and cold?

Why are freezing and melting necessarily gradual processes?

What effect has a heavy rainfall on the temperature of the atmosphere?

Explain the cause of deserts.

Define subterranean drainage. Surface drainage.

Upon what does the quantity of water discharged by a spring in a given time depend?

Explain the cause of periodical springs.

What is the temperature of cold springs? Of hot or thermal springs?

What is the probable cause of the high temperature of hot springs?

How can the probable depth of the reservoir of an artesian spring be ascertained from the temperature of its waters?

What are geysers? Explain the cause of their eruption.

What is the origin of the tube and basin of the geyser?

Name the three largest geyser regions of the world.

What is travertine? How is it formed?

Name some of the most important springs from which large quantities of salt are obtained.

What is believed to be the origin of petroleum or coal oil?

How are the precipices of waterfalls caused? In what courses of a river are they most common?

Name the highest waterfall in the world. The grandest.

Distinguish between an estuary and a delta.

How does the destruction of the forest increase the severity of inundations?

Upon what does the quantity of water in a river depend?

In what different portions of a stream may the silt or detritus be deposited?

What are rafts? How are they caused?

Explain the formation of fluviatile islands and lakes.

Name some of the most extensive delta-formations in North America. In Europe. In Asia. In Africa.

What is the probable origin of the swamp-lands of the Atlantic seaboard?

How may a tolerably accurate notion of the direction of the slopes of a country be obtained by a study of the direction of its rivers?

In what respects do the drainage of North and South America resemble each other?

Name the principal systems of inland drainage of the world.

Explain the cause of the saltness of inland waters.

MAP QUESTIONS.

Which ocean drains the largest areas of the continents? Which the smallest?

Name the important rivers which drain into the Atlantic from North America. From South America. From Europe. From Africa.

Name the important rivers which drain into the Pacific from North America. From Asia.

Name the important rivers which drain into the Indian Ocean from Africa. From Asia. From Australia.

What two systems of inland drainage are there in North America? What large region in South America?

Name an important steppe lake and river in each of the continents.

Describe the region of inland drainage of Europe and Asia. What large lakes and rivers belong to this region?

Describe the regions of inland drainage of Africa. Of Australia. Name the important lakes found in each region.

What South American river corresponds in the direction of its drainage with the St. Lawrence? With the Mackenzie? With the Mississippi?

Name the large rivers which drain the predominant mountain-system of Asia. Of Europe. Of Africa. Of North America. Of South America. Of Australia.

Describe the fresh-water lake-region of North America. Of South America. Of Europe. Of Africa.

In which line of trend are most of the fresh-water lakes of North America found?

Name the Atlantic rivers which have large deltas The Pacific rivers. The Indian rivers.

Section II.

OCEANIC WATERS.

CHAPTER I.

The Ocean.

194. Composition.—The water of the ocean contains a number of various saline ingredients, which give it a bitter taste and render it heavier than fresh water in the proportion of 1.027 to 1.

Every hundred pounds of ocean-water contains about three and one-third pounds of various saline ingredients.

Chloride of sodium, or common salt, chloride of magnesium, sulphates and carbonates of lime, magnesia, and potassa, and various bromides, chlorides, and iodides, are the principal saline ingredients.

195. Origin of the Saltness of the Ocean.—The rivers are constantly dissolving from their channels large quantities of mineral matters, and pouring them into the ocean. Besides this, fully three-fourths of the earth's surface is covered permanently by the oceanic waters. In this way immense quantities of mineral ingredients have been dissolved out from the crust. The latter cause was especially active during the geological past, when frequent convulsions brought fresh portions of the crust into contact with the warm waters.

The ocean is salter in those parts where the evaporation exceeds the rainfall, or at about the latitude of the tropics; where the rainfall exceeds the evaporation, the water is slightly fresher than at the equator.

In inland seas, like the Mediterranean or the Red Sea, which, though connected with the ocean, yet lose much more of their waters by evaporation than by outflow, the proportion of salt is slightly greater than in the ocean. In such cases a current generally flows into the sea from the ocean. In colder latitudes, inland seas, like the Baltic, receiving the waters of large rivers, contain rather less salt than the open sea, and a current generally flows from them into the ocean.

196. Color.—Though transparent and colorless in small quantities, yet in large masses the color of sea-water is a deep blue. The same is true of fresh water. Over limited portions of the ocean the waters are sometimes of a reddish or a greenish hue, from the presence of numberless minute organisms.

Sometimes a pale light or phosphorescence, visible only at night, and due to the presence of animalculæ, appears where the air comes into contact with the water, as in the wake of a vessel or on the crests of the waves.

197. Temperature.—The salts dissolved in ocean-water lower the temperature of its freezing-point. Ordinary ocean-water freezes at about 27° F. In places where the water is salter, the temperature of its freezing-point is lower.

Ice formed from ocean-water is comparatively fresh, nearly all the salt being separated as the water freezes or crystallizes. The salt, thus thrown out from the frozen water, is dissolved by the water below, lowers the temperature of its freezing-point, and thus increases its density. In this manner the water below the ice may have a temperature lower than that at which the surface-water freezes, and yet remain liquid.

In the polar regions the water below the surface is at a temperature lower than that of the freezing-point of the surface-water. This cold water, from its greater density, spreads over the floor of the ocean in all latitudes, so that, except where stirred by deep currents, the entire bottom of the ocean is covered with a layer of dense, heavy water, the temperature of which is nearly *constant.*

The temperature of this water is about 35° F. Near the poles it is somewhat lower: about 29°, or a little higher than its maximum density of the surface-waters.

The upper limit of this *line of invariable temperature* varies with the latitude. Near the equator, where the waters are heated to great depths, it is found at about 10,000 feet below the surface. Toward the poles, it comes nearer the surface, reaching it at about Lat. 60°, from which point it again sinks, being found at Lat. 70° at about 4500 feet below the surface.

In the tropics *the temperature of the surface-water* is about 80° F.; in the polar regions it is near the freezing-point. The ice which forms in the polar regions collects in vast *ice-fields* or *floes.*

198. Shape of the Bottom of the Ocean.—The bed of the ocean, though diversified like the surface of the land, contains fewer irregularities. Numerous soundings show that it extends for immense distances in long undulations and slopes. Its plateaus and plains, therefore, are of great size, compared with those of the continents. Submerged mountain-ranges occur both in the deep ocean and along the shores. The latter belong, properly, to the continental systems of elevations.

199. The Oceanic Areas.—The ocean is one continuous body of water, but for purposes of description and study it is generally divided into five smaller bodies: the *Pacific, Atlantic, Indian, Arctic,* and *Antarctic* Oceans. The last two are separated from the preceding by the polar circles; the others are separated mainly by the continents. As the continents do not extend to the Antarctic Circle, the meridians of Cape Horn, Cape of Good Hope, and South Cape in Tasmania, are taken as the ocean boundaries south of these points.

The following table gives the relative size of the oceanic areas:

The Pacific	occupies	about	$\frac{1}{2}$	the entire	water-area.
" Atlantic	"	"	$\frac{1}{4}$	"	"
" Indian	"	"	$\frac{1}{5}$	"	"
" Antarctic	"	"	$\frac{1}{17}$	"	"
" Arctic	"	"	$\frac{1}{35}$	"	"

200. Articulation of Land and Water.—The indentations of the oceans, or the lines of junction between the water and the land, may be arranged under four heads:

(1.) **Inland Seas**, or those surrounded by a nearly continuous or unbroken land-border; as the Gulf of Mexico, Hudson Bay, the Baltic, and the Mediterranean, in the Atlantic; the Red Sea and the Persian Gulf, in the Indian; and the Gulf of California, in the Pacific.

(2.) **Border Seas**, or those isolated from the rest of the ocean by peninsulas and island chains; as the Caribbean Sea, the Gulf of St. Lawrence, and the North Sea, in the Atlantic; and Bering Sea, the Sea of Okhotsk, the Sea of Japan, and the North and South China Seas, in the Pacific.

(3.) **Gulfs and Bays**, or broad expansions of the water extending but a short distance into the land; as the Gulf of Guinea and the Bay of Biscay, in the Atlantic; and the Bay of Bengal and the Arabian Sea, in the Indian.

(4.) **Fiords**, or deep inlets, with high, rocky headlands, extending often from 50 to 100 miles into the land. One of the best instances of this form of indentation is off the Norway coast. According to Dana, fiords are valleys that were excavated by vast ice-masses called glaciers, but which have since become partially submerged by the gradual subsidence of the land.

Fiord valleys occur on the Norway coast, on the coasts of Greenland, Labrador, Nova Scotia, and Maine, on the western coast of Patagonia and Chili, and on the western coast of North America north of the Straits of Fuca. On parts of the coast of Greenland the glaciers are now cutting out their partially submerged valleys, and forming what will probably become fiord valleys.

The Atlantic Ocean is characterized by inland seas; the Pacific, by border seas; the Indian, by gulfs and bays; the Atlantic and the Pacific, by fiords.

201. Depth of the Ocean.—The mean depth of the ocean is about 12,000 ft., or nearly $2\frac{1}{4}$ miles. Recent soundings give the greatest depth of the Atlantic, in the neighborhood of the island of St. Thomas of the West Indies, as 27,000 feet. The greatest depth in the Pacific, as reported by recent careful soundings, occurs east of Japan, and is 27,930 ft. These give a depth of about $5\frac{1}{4}$ miles, or less than the greatest elevation of the land. It is probable, however, that some portions of the ocean are much deeper.

The greater depressions of the ocean are called *deeps*, the shallower portions are called *rises.*

202. The Pacific Ocean.—The shape of the shore-line of the Pacific is that of an immense oval, nearly closed at the north, but broad and open at the south.

As indicated by the island chains, a number of shallow places, or rises, extend in the direction of the north-west trend: the summits of those on the north form the Sandwich Islands, and the summits of those on the south form the Polynesian Island chain.

203. The Atlantic Ocean.—The shape of the shore-line of the Atlantic is that of a long, trough-like valley, with nearly parallel sides. The Atlantic has a broad connection with both the polar oceans, and forms the only open channel for the intermingling of the warm and cold waters.

Shape of the Bed.—Recent soundings in the Atlantic show the presence of a submarine plateau extending in mid-ocean parallel to the coasts of the continents from the latitude of the southern point of Africa to Iceland, thus dividing the basin into eastern and western valleys. The western valley is the deeper; the average depths of the two being respectively 18,000 and 13,000 feet. A remarkable

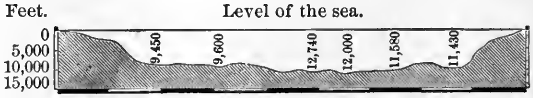


Fig. 69. The Telegraphic Plateau.

plateau extends across these valleys, from Newfoundland to Ireland. Its depth ranges from 10,000 to nearly 13,000 feet. It is called the Telegraphic Plateau, and bears a number of telegraphic cables. The eastern and western valleys, though less marked in this region, are still distinguishable.

The true bed of the ocean begins at a considerable distance from the eastern coast of North America. For distances of from 75 to 100 miles, the depth scarcely exceeds 600 feet; but from this point it descends, by steep terraces, to profound depths.

The British Isles are connected with the continent of Europe by a large submerged plateau, which underlies nearly the whole North Sea, and extends for considerable distances off the western and southern coasts. The depth of this part of the ocean is nowhere very great.

204. The Indian Ocean.—The shape of the shore-line is, in general, triangular. This ocean has no connection with the Arctic, but is entirely open on the south, where it merges into the great water-area of the globe: the basins of the Antarctic and Pacific.

Shape of the Bed.—A submarine plateau extends to the south off the western coast of Hindostan. Its summits form the Laccadive, Maldive, and Chagos Islands, and possibly extends in the same direction as far as Kerguelen Island.

205. The Antarctic and Arctic Oceans.—The shore-line of the Arctic has the shape of an irregular ring. The shore-line of the Antarctic is probably of the same shape.

But little is known concerning the beds of these oceans. From the very limited land-areas south of lat. 50° S., the bed of the Antarctic is presumably deeper than that of the Arctic, except toward the south pole, where it is probably shallower.

206. Ooze Deposits.—Foraminiferal Land.—The reef-forming coral polyps are not the only animalculæ the accumulation of whose bodies after death add to the land-masses of the earth. Deep-sea soundings show that over extended areas

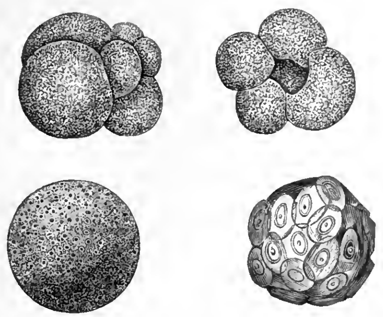


Fig. 70. Foraminifera.

the floor of the ocean is evenly covered with a creamy layer of mud or ooze, which, like the deposits of the coral animalculæ, is composed principally of carbonate of lime. This ooze consists almost entirely of microscopic skeletons of a group of animalculæ known as the Foraminifera, from the great number of perforations or openings in their hard parts. These animalculæ are so small that 1,000,000 are equal in bulk to only one cubic inch. They appear to live in the layers of water near the surface, and after death to fall gradually to the bottom of the sea. Soundings show their presence over very extended areas.

Many of the very deep parts of the ocean's bed are covered, not with foraminiferal deposits, but with a layer of red mud composed of finely-divided clay. Its origin is probably as follows: In very deep parts of the ocean before the foraminiferal deposits reach the bottom their limey matters are dissolved, and the undissolved parts form the deposits of fine red mud.

CHAPTER II.

Oceanic Movements.

207. The Oceanic Movements can be arranged under three heads: *waves, tides,* and *currents.*

Waves are swinging motions of the water, caused by the action of the wind. Their height and velocity depend on the force of the wind, and the depth of the basin in which they occur. The stronger the wind, and the deeper the ocean, the higher the waves and the greater their velocity.

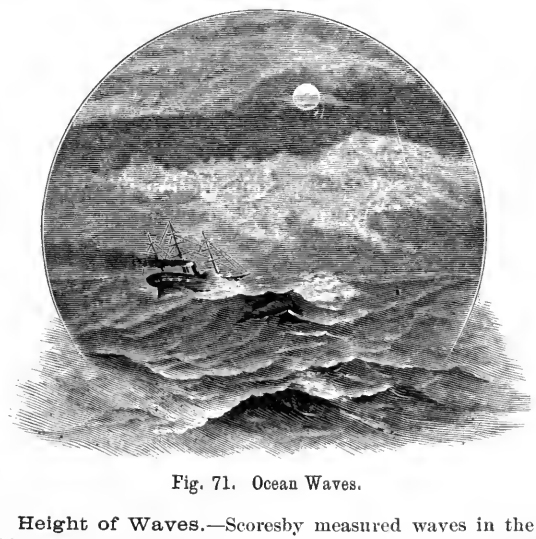


Fig. 71. Ocean Waves.

Height of Waves.—Scoresby measured waves in the North Atlantic 43 feet above the level of the trough. Waves have been reported in the South Atlantic, off the Cape of Good Hope, between 50 and 60 feet high. Navigators have occasionally reported higher waves, but the accuracy of their measurements is, perhaps, to be doubted. In the open sea, with a moderate wind, the height of ordinary waves is about 6 feet.

The distance between two successive crests varies from 10 to 20 times their height. Waves 4 feet high have their successive crests 40 feet apart; those 33 feet high, about 500 feet apart.

208. No Progressive Motion of Water in Waves.—In wave motion, the water seems to be moving in the direction in which the wave is advancing, but this is only apparent; light objects, floating on the water, rise and fall, but do not move forward with the wave. In shallow water, however, the water really advances. The forward motion of the wave is retarded, so that the waves following reach it, thus increasing its height. The motion at the bottom is lessened, and the top curls over and breaks, producing what are called *breakers.*

On gently sloping shores, the water which runs down the beach, after it has been thrown upon it by the breakers, forms, at a little distance from the shore, the dreaded "undertow" of our bathing-resorts.

Force of the Waves.—When high, and moving in the direction of the wind, the waves dash against any obstacle, such as a line of coast, with great force, and may thus cut it away and change the coast-line. This action occurs only on exposed, shelving coasts. The wave-motion is, in general, very feeble at 40 feet below the surface. The eroding action of the ocean waves is, therefore, far inferior to that of the continental waters.

209. Tides are the periodical risings and fallings of the water, caused by the *attraction of the sun and moon.* The alternate risings and fallings succeed each other with great regularity, about every six hours. Unlike waves, in which the motion is confined practically to the surface waters only, tides affect the waters of the ocean from top to bottom.

The rising of the water is called *flood tide;* the falling, *ebb tide.* When the waters reach their highest and lowest points, they remain stationary for a few minutes. These points are called, respectively, *high* and *low water.* Corresponding high or low water, at any place, occurs fifty-two minutes later each successive day.

210. Theory of the Tides.—If the earth were uniformly covered with a layer of water, the passage of the moon over any place, as at *a*, Fig. 72, would cause the water to lose its globular form, become bulged at *a*, and *b*, and flattened at *c*, and *d*. In other words, the water would become *deeper* at *a*, and *b*, at the parts of the earth nearest and farthest from the moon, and *shallower* in

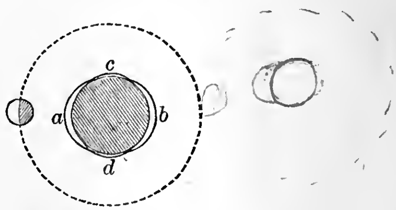


Fig. 72. Lunar Tide.

all places 90° or at right angles to these points, such, for example, as at *c*, and *d*.

This deepening and shallowing of the water is caused by the attraction of the moon. As the moon passes over *a*, the water is drawn toward the moon, thus deepening the water directly under the moon, and shallowing it at *c*, and *d*.

The cause of the deepening of the water at *b*, on the side farthest from the moon, is as follows: the solid earth being, as a whole, nearer the moon than the water at *b*, but farther from it than that at *a*, must take a position which will be nearly midway between *a*, and *b*, leaving a protuberance at *b*, nearly equal to that at *a*.

The protuberances *a*, and *b*, mark the position of *high tides.* At all points of the earth 90° from the protuberances, as at *c*, and *d*, the depression is greatest. These mark the position of *low tides.*

High tides, then, occur at those points of the earth's surface which are cut by a straight line, which passes through the centre of the earth and that of the attracting body, as the sun or moon. Low tides are found at right angles to these points.

Had the earth no rotation, the tidal waves, so formed, would slowly follow the moon in its motion around the earth. But, by the rotation of the earth, different parts of its surface are rapidly brought under the moon, and the tidal waves, consequently, move rapidly from one part of the ocean to another.

Had the moon no motion around the earth, there would be two high tides and two low tides every 24 hours. While, however, the earth is making one complete rotation, the moon, in its motion around the earth, has changed its position, and the earth rotates for 52 minutes longer before the same point again comes directly under the moon.

Since the uniformity of the water surface is broken by the elevations of the land, the progress of the tidal wave is greatly affected by the size, shape, and depth of the oceanic basin, and the position of the continents. Owing to the obstructions offered by the continents, and by inequalities in the bed of the ocean, a very considerable retardation of the tidal wave is effected, so that a high tide may not occur at a place until long after the moon has passed over it.

Solar Tides.—The sun also produces a system of tidal waves, but owing to its greater distance from the earth, the tides thus produced are much smaller than those of the moon, upon which, therefore, they exert but a modifying influence. The tide-producing power of the moon is greater than that of the sun, in about the proportion of 800 to 355. That is, the tide produced by the moon is about $2\frac{1}{4}$ times greater than that produced by the sun.

The tidal wave moves, in general, from *east to west, or in the opposite direction to the rotation of the earth.* The motion of so large a mass of water thus opposed to the earth's rotation, must gradually diminish the axial velocity, and, eventually, entirely stop the rotation of the earth; in this way an increase in the length of day and night should be produced, but so far, however, no increase has been detected, although astronomical observations extend backward for long periods. The increased axial velocity, produced by the contraction of the globe, probably balances the retarding influence of the tides.

In the deep ocean, and near the mouths of rivers, the duration of the flood and ebb are about equal; but in most rivers, at some distance from the mouth, the *ebb is longer than the flood.* The cause is to be found in the fact that the outflowing river current meets and temporarily neutralizes the inflowing flood tide, thus diminishing its duration, and afterward, adding its motion to the ebb, makes the difference between the two still greater.

The tidal wave often ascends a stream to a much greater elevation above the level of its mouth than the height of the tide at the river's mouth. In large rivers, like the Amazon, the tidal wave advances up the river as much as 100 feet above the sea-level.

Some of the proofs of the connection between the tides and the attraction of the moon and sun are as follows:

(1.) The interval between corresponding high tides at any place is the same as the interval between two successive passages of the moon over that place: 24 hours, 52 minutes.

(2.) The tides are higher when the moon is nearer the earth.

(3.) The tides are higher when the sun and moon are simultaneously acting to cause high tides in the same places

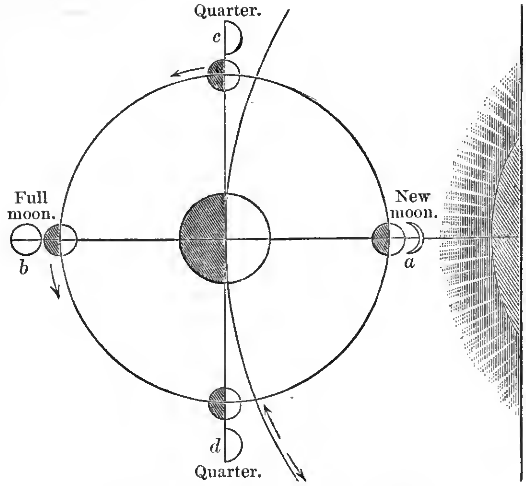


Fig. 73. Cause of the Phases of the Moon.

Phases of the Moon.—An inspection of Fig. 73 will show, that during new and full moon, the earth, moon, and sun are all in the same straight line, but, that during the first and last quarters, they are at right angles. The portions of the earth and moon turned toward the sun are illumined, the shaded portions are in the darkness. To an observer on the earth, the moon, at *a*, appears new, since the dark part is turned toward him; at *b*, however, it must appear full, since the illumined portions are toward him. At *c*, and *d*, the positions of the quarters, only one-half of the illumined half, or one quarter, is seen.

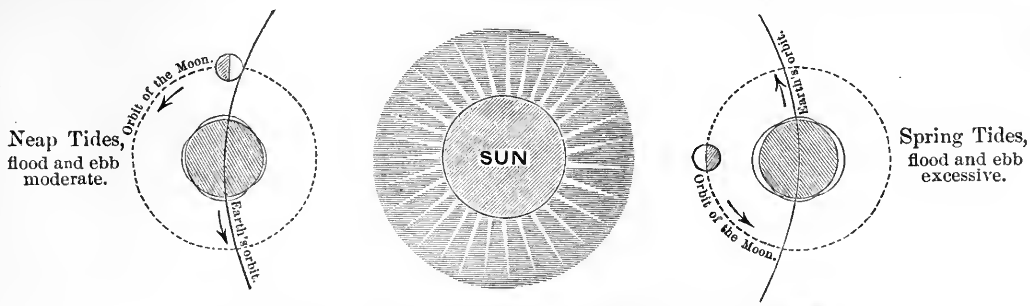


Fig. 74. Position of the Earth, Moon, and Sun during Spring and Neap Tides.

211. Spring and Neap Tides.—When the sun and moon act simultaneously, on the same hemisphere of the earth, as shown in Fig. 74, the tidal wave is higher than usual. The flood tides are then highest, and the ebb tides lowest. These are called *spring tides.* They occur twice during every revolution of the moon—once at *full,* and once at *new* moon. The highest spring tides occur a short time before the March and the September equinoxes, when the sun is over the equator, and is nearest the earth.

When, however, the sun and moon are 90°

10

apart, or in quadrature, each produces a tide on the portion of the earth directly under it, diminishing somewhat that produced by the other body. High tide, then, occurs under the moon, while the high tide caused by the sun, becomes, by comparison, a low tide. Such tides are called *neap tides*. During their prevalence, the flood is not very high, nor the ebb very low. They occur twice during each revolution of the moon, but are lowest about the time of the June and December solstices.

The average relative height of the spring tide to that of the neap tide is about as 7 to 4.

212. Birthplace of the Tidal Wave.—Although a tidal wave is formed in all parts of the ocean where the moon is overhead, yet the "Cradle of the Tides" may properly be located in the great southern area of the Pacific Ocean. Here the combined attraction of the sun and moon originate a wave, which would travel around the earth due east and west, with its crests north and south; but, meeting the channels of the oceans, it is forced up them toward the north. *Its progress is accelerated in the deep basins, and retarded in the shallow ones.* On striking the coasts of the continents, deflected or secondary waves move off in different directions, thus producing great complexity in the form of the parent wave.

213. Co-Tidal Lines.—The progress of the tidal wave, in each of the oceans, is best understood by tracing on a map, lines connecting all places which receive the tidal wave at the same time. These are called *co-tidal* lines. The distance between two consecutive lines represents the time, in hours, required for the progress of the tidal wave. In parts of the ocean where the wave travels rapidly the co-tidal lines are far apart; when its progress is retarded, they are crowded together.

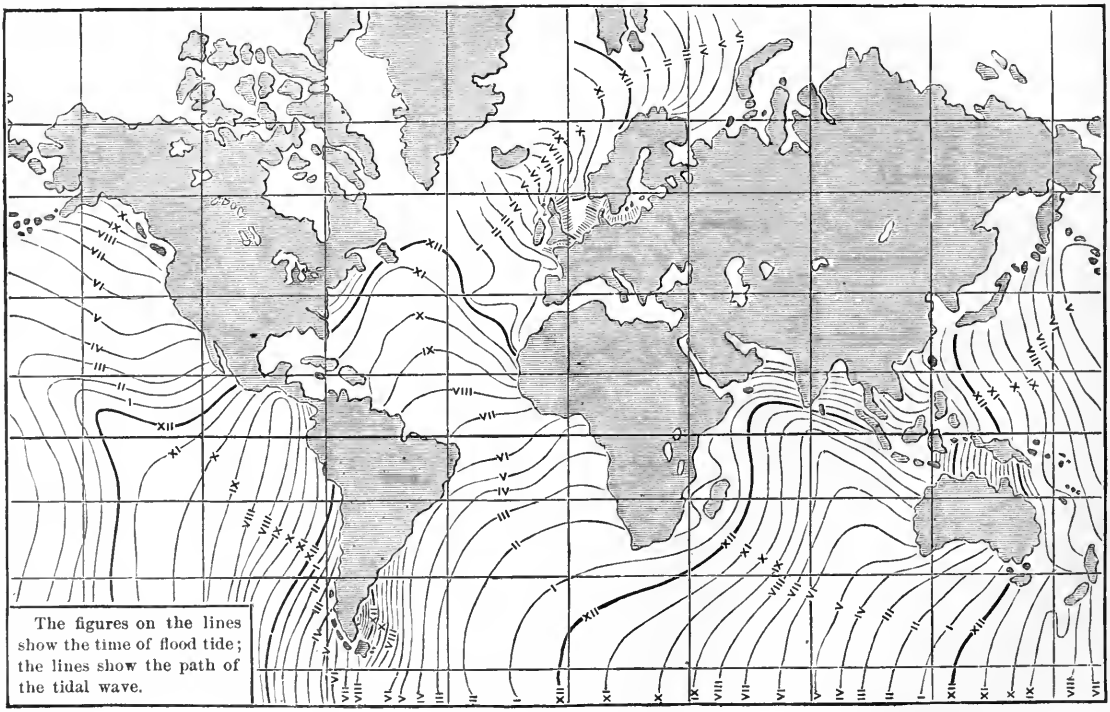


Fig. 75. Co-Tidal Chart.

Since it is only possible to take the height of the tide on the coasts of islands and of the continents, the tracks of the co-tidal lines must be to a considerable extent conjectural.

214. The Pacific Ocean.—Twice every day a tidal wave starts in the south-eastern part of the Pacific Ocean, west of South America, somewhere between the two heavy lines marked XII on the chart. It advances rapidly toward the north-west in the deep valley of this ocean, reaching Kamtchatka in about 6 hours. Toward the west its progress is retarded by the shallower water, and by the numerous islands, so that it only reaches New Zealand in about 6 hours and enters the Indian Ocean in about 12 hours.

215. The Indian Ocean.—The 12-hour-old tidal wave from the Pacific, meets and moves along with a wave started in this ocean by the moon, and advances in the direction indicated by the co-tidal lines entering the Atlantic Ocean about 12 hours afterward.

216. The Atlantic Ocean.—The tidal wave from the Indian joins two other waves, one formed by the moon in this ocean, and the other a deflected wave that has backed into the Atlantic from the Pacific. The tidal wave thus formed advances rapidly up the deep valley of the Atlantic, reaching Newfoundland 12 hours afterward, or 48 hours after it started in the Pacific. It then advances rather less rapidly toward the north-east, reaching the Loffoden Islands 12 hours afterward, or 60 hours after leaving its starting-place in the Pacific.

217. Tides in Inland Seas and Lakes are very small and, consequently, difficult to detect. In the Mediterranean Sea the tides on the coasts average about 18 inches. The tide in Lake Michigan is about $1\frac{3}{4}$ inches.

218. Height of Tidal Wave.—Ocean tides are lowest in mid-ocean, where they range from two to three feet. Off the coasts of the continents, especially when forced up narrow, shelving bays, deep gulfs, or broad river mouths, they attain great heights. The cause of these unusual heights is evident. When the progress of the tidal wave is retarded, either by the contraction of the channel or by other causes, the following part of the wave overtakes the advanced part, and thus, *what the wave loses in speed it gains in height, from the heaping up of the advancing waters. Where the co-tidal lines, therefore, are crowded together on the chart, high tides are likely to occur;* for example, the Arabian Sea and Bay of Bengal, the North and South China Seas, the eastern coasts of Patagonia, the Bay of Fundy, the English Channel, and the Irish Sea, *have very high tides.*

Near the heads of the Persian Gulf and China Seas, the tides sometimes rise about 36 feet. At the mouth of the Severn, the spring tides rise from 45 to 48 feet; on the southern coast of the English Channel, 50 feet; and in the Bay of Fundy, near the head, the spring tides, aided by favoring winds, sometimes reach 70 feet, and, occasionally, even 100 feet.

A strong wind, blowing in the direction in which the tidal wave is advancing, causes an increase in the height of the tide.

A low barometer is attended by a higher tide than usual; a high barometer, by a lower tide.

219. Other Tidal Phenomena.

The Bore or Eager.—On entering the estuary of a river, the volume of whose discharge is considerable, the onward progress of the tidal wave is checked; but, piling up its waters, the incoming tide at last overcomes the resistance of the stream, and advances rapidly, in several huge waves. The tides of the Hoogly, the Elbe, the Weser, and the Amazon, are examples. In the latter river, the wave is said to rise from 30 to 50 feet.

Races and Whirlpools.—When considerable differences of level are caused by the tides, in parts of the ocean separated by narrow channels, the waters, in their effort to regain their equilibrium, move with great velocity, producing what are called *races*. At times, several races meet each other obliquely, thus producing *whirlpools*. Near the Channel Islands, and off the northern coasts of Scotland, races are numerous. The *Maëlstrom*, off the coasts of Norway, is an instance of a whirlpool, though the motion of the waters is not exactly a whirling one. The main phenomenon is a rapid motion of the waters, alternately backward and forward, caused by the conflict of tidal currents off the Loffoden Islands.

CHAPTER III.

Ocean Currents.

220. Constant Ocean Currents.—Besides tidal currents, the waters of the ocean are disturbed to great depths, by currents, moving with considerable regularity to and from the equatorial and polar regions, and thus producing a constant interchange of their waters. These movements are called *constant currents*, and, unlike waves, consist in a real, onward movement of the water.

Constant currents resemble rivers, but are immensely broader and deeper. As a rule, their temperature differs considerably from that of the waters through which they flow. They are not confined to the surface, but exist as well at great depths, when they are called *under or counter currents*, and flow in a *direction opposite to that of the surface currents.*

221. The Principal Cause of Constant Ocean Currents is the difference of density of the water produced by the differences of temperature between the equatorial and the polar regions.

As the waters of the polar regions lose their heat they become denser, and, sinking to the bottom, form a mountain-like accumulation of dense, cold water, which, as rapidly as formed, spreads over the floor of the ocean underneath the lighter waters. The consequent lowering of the level of the polar waters causes an influx of the surface waters from the equatorial regions. In this manner a constant interchange is effected between the equatorial and polar regions, which, for the greater part, takes place along the bottom from the poles to the equator, and along the surface from the equator to the poles. Since, however, the pole is a mere point, this interchange occurs mainly between the equator and the polar circles.

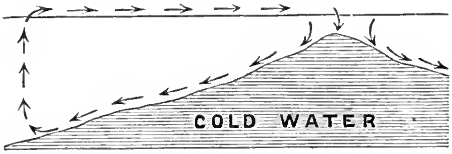


Fig. 76. Currents caused by Difference of Temperature.

Thus in Fig. 76, the mountain-like accumulation is shown as having its crest at about the latitude of the polar circle. The arrows show the direction of the currents. At the equatorial regions, the surface water is warmer and lighter, and at the polar regions, probably, colder and lighter.

As a rule, the warm currents are on the surface, and the cold currents, from their greater density, are underneath them. In shallow oceans, however, the cold currents come to the surface, thus displacing the warm currents and deflecting them to deeper parts of the ocean.

Had the earth no rotation on its axis, this interchange would be due north and south, or would take place directly between the equatorial and polar regions. On account of the earth's rotation, however, and a variety of other causes, these north-and-south directions are considerably changed. The principal of these deflecting causes are—

(1.) The earth's rotation;
(2.) The position of the land masses
(3.) The winds;
(4.) Differences of density caused by evaporation;
(5.) Differences of level caused by evaporation.

The changes in direction caused by the earth's rotation and the position of the land masses are as follows: as the waters are in constant motion, the polar waters reach the equatorial regions with an eastward motion less than that of the earth. In the equatorial regions, therefore, the waters are unable to acquire the earth's motion toward the east, and are left behind; that is, the earth, slipping from under them, causes them to cross the ocean at *a*, *a'*, Fig. 77, from east to west, although they are in reality moving with the earth toward the east.

Reaching the western borders of the oceans, near *b*, *b'*, the continents prevent their going farther west, and deflect them into northern and southern branches, and they begin to move toward the poles.

From *c*, to *d*, and from *c'*, to *d'*, the poleward-moving waters are deflected toward the east in both hemispheres. The waters on reaching *c*, from *a*, and *b*, still retain the eastward motion they acquired while moving with the

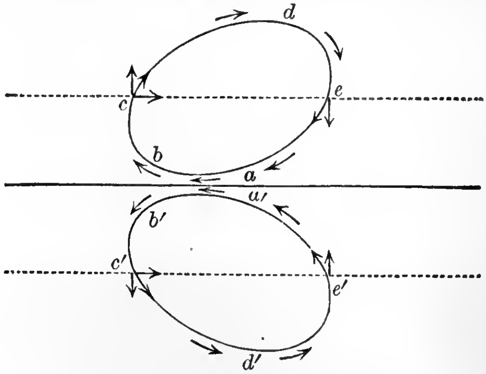


Fig. 77. Deflections of Ocean Currents.

earth. This motion is greater than that of the earth between *c*, and *d*. Between these points, therefore, the water is acted on by two forces, one tending to carry it toward the poles, and the other tending to carry it eastward. The resultant of these forces carries the water from *c*, to *d*, and from *c'*, to *d'*, or toward the *north-east* in the Northern, and toward the *south-east* in the Southern Hemisphere.

Between *d*, and *e*, and *d'*, and *e'*, the waters still retain this excess of eastward motion, and, therefore, move in the directions shown.

Between *e*, and *a*, and *e'*, and *a'*, the waters in both hemispheres are deflected toward the west because they are unable to acquire the earth's motion toward the east. Another, and perhaps the main, cause of this westward deflection is the depression caused by the westward movement of the equatorial waters at *a*, and *a'*.

The action of the winds is to tend to move the surface waters in the direction in which they are blowing. This action is by some authorities regarded as the principal cause of constant currents.

The difference in the density of the water, caused by evaporation, leaving the water salter and denser in some parts, and fresher and lighter in others, probably acts to some extent as a deflecting cause. For example, the water evaporated near the equator, and precipitated, for the greater part, in regions near the borders of the tropics, renders the regions salter and denser from which it was evaporated, and fresher and less dense where it is precipitated.

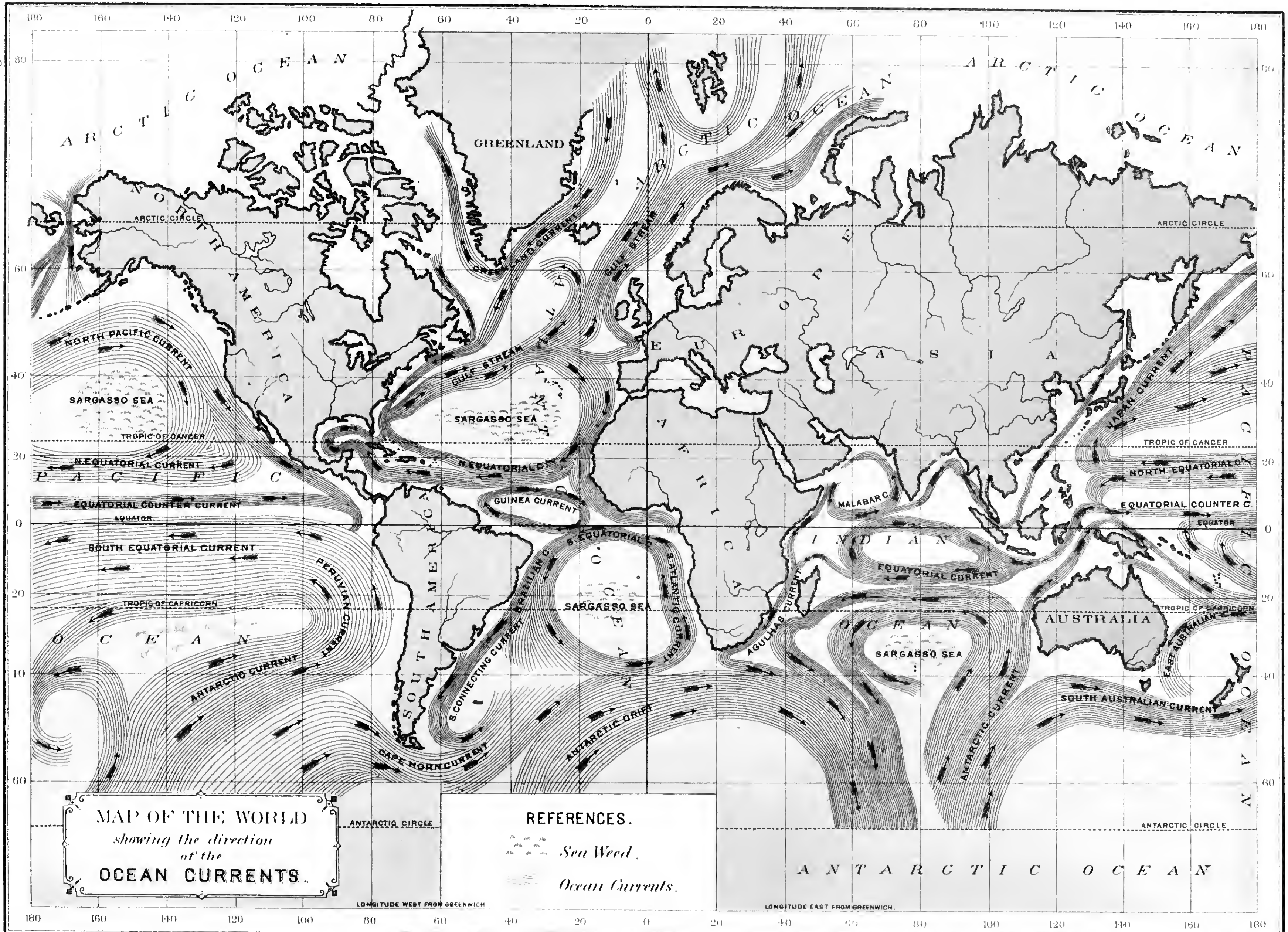
The difference in level caused by the greater evaporation in the equatorial regions north of the equator than in corresponding latitudes in the Southern Hemisphere has been ascribed as one of the causes of the flow of Antarctic waters toward the equator.

222. General Features of Constant Currents.—The following motions of the *surface currents* are common to all the three central oceans:

(1.) A movement of the equatorial waters, *a*, *a*, from east to west;

(2.) Their deflection into northern and southern branches (*b* and *c*), on reaching the western borders of the ocean;

(3.) A movement of the waters beyond the equator from west to east (*d*, *e*);


MAP OF THE WORLD
showing the direction
of the
OCEAN CURRENTS.
REFERENCES.
Sea Weed.
Ocean Currents.
ARCTIC OCEAN
PACIFIC OCEAN
ATLANTIC OCEAN
INDIAN OCEAN
ANTARCTIC OCEAN
NORTH AMERICA
SOUTH AMERICA
GREENLAND
EUROPE
ASIA
AFRICA
AUSTRALIA
NORTH PACIFIC CURRENT
SARGASSO SEA
TROPIC OF CANCER
N. EQUATORIAL CURRENT
EQUATORIAL COUNTER CURRENT
EQUATOR
SOUTH EQUATORIAL CURRENT
TROPIC OF CAPRICORN
PERUVIAN CURRENT
ANTARCTIC CURRENT
CAPE HORN CURRENT
GREENLAND CURRENT
GULF STREAM
N. EQUATORIAL C.
GUINEA CURRENT
S. EQUATORIAL C.
BRAZILIAN C.
S. CONNECTING CURRENT
S. ATLANTIC CURRENT
ANTARCTIC DRIFT
AGULHAS CURRENT
MALABAR C.
EQUATORIAL CURRENT
SOUTH AUSTRALIAN CURRENT
EAST AUSTRALIAN C.
JAPAN CURRENT
NORTH EQUATORIAL C.
EQUATORIAL COUNTER C.
ARCTIC CIRCLE
ANTARCTIC CIRCLE
LONGITUDE WEST FROM GREENWICH
LONGITUDE EAST FROM GREENWICH

(4.) A separation of these latter currents into two branches (*f, g* and *h, i*), one continuing toward

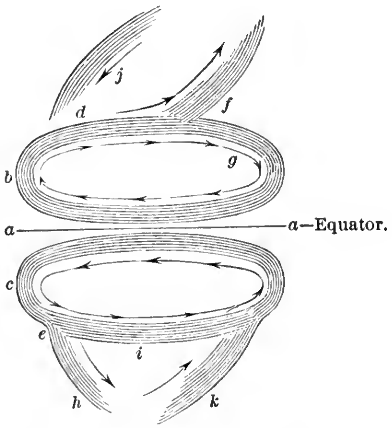


Fig. 78. Chart of Constant Currents.

the poles, and the other toward the equator, where they join with the equatorial currents, thus completing a circuit in the shape of a vast ellipse;

(5.) A flow of the Arctic waters along the western border of the ocean (*j*), and of the Antarctic along the eastern (*k*).

Since the Indian Ocean is completely closed on the north, only part of the above movements are observed. In the Pacific, an equatorial counter-current crosses the ocean from west to east.

223. Currents of the Atlantic.—The equatorial current crosses the ocean, from east to west, in two branches: a south equatorial current, which comes from the Antarctic, and a north equatorial current, which comes mainly from regions north of the equator.

The north equatorial current flows along the north-east coast of South America, and, for the greater part, enters the Caribbean Sea and Gulf of Mexico, and emerges between Florida and Cuba as the Gulf Stream.

The Gulf Stream flows along the eastern coast of North America, with a velocity of from four to five miles per hour, and in mid-ocean, between Newfoundland and Spain, divides, one branch flowing toward Norway, Spitzbergen, and Nova Zembla, the other flowing southward, down the coasts of Africa, where it forms the main feeder of the north equatorial current.

The south equatorial current, after crossing the ocean, flows south along the Brazilian coast, and divides near Rio Janeiro, the main part flowing eastward and mingling with the Antarctic current, and the remainder continuing down the eastern coast of South America. Cold currents from the Arctic flow down the coasts of Greenland and Labrador. A broad polar current sweeps from the Antarctic Ocean, and forms the main feeder of the south equatorial current, but passes in greater part eastward, south of Africa.

A small elliptical current flows near the equator, between the north and south equatorial currents.

224. Currents of the Pacific.—North and south equatorial currents flow from east to west, and between them a smaller, less powerful equatorial counter-current, from west to east. The south equatorial current, fed by the broad Antarctic current, is the larger of the two.

The north equatorial current, on reaching the Philippine Islands, divides into northern and southern branches; a portion of its southern branch returns with the equatorial counter-current, while the northern branch, the main portion, flows north-east along the Asiatic coast as the *Kuro Sivo,* the counterpart of the Gulf Stream. At about Lat. 50°, this flows eastwardly as a *North Pacific* current, and off the shores of North America it returns, in an elliptical path, southerly to the north equatorial current, forming its main feeder. A small current flows through the eastern side of Bering Strait, into the Arctic Ocean.

The south equatorial current of the Pacific is broken into numerous branches during its passage through the islands in mid-ocean. Reaching the Australian continent and the neighboring archipelagoes, it sends small streams toward the north, but the main portion flows south, along the Australian coast, when, flowing eastward, it merges with the cold *Antarctic current.*

The Antarctic current moves as a broad belt of water toward the north-east, when, flowing up the western coast of South America, it turns to the west, and forms the main feeder of the south equatorial current. A part of the Antarctic current flows eastward, south of South America, and enters the Atlantic as the Cape Horn current.

A small cold current from the Arctic flows through Bering Strait, down the Asiatic coast.

225. Currents of the Indian Ocean.—Only a *south equatorial current* exists, which flows down the eastern and western coasts of Madagascar, and down the African coast to Cape Agulhas, when, turning eastward, it merges with the Antarctic current, and flows up the western coast of Australia, where it joins the equatorial current.

The north equatorial current in this ocean is indistinct—

(1.) Because the ocean has no outlet to the north;

(2.) Powerful seasonal winds, called the monsoons, move the waters alternately in different directions, as huge drift currents.

Sargasso Seas.—Near the centre of the elliptical movement in each of the central oceans, masses of seaweed have collected where the water is least disturbed. These are called *sargasso seas.*

226. Utility of Currents:

(1.) They moderate the extremes of climate by carrying the warm equatorial waters to the poles, and the cold polar waters to the equator;

(2.) They increase materially the speed of vessels sailing in certain directions;

(3.) They transport large quantities of timber to high northern latitudes.

SYLLABUS.

Ocean water contains about three and one-third pounds of various saline ingredients, in every one hundred. Chloride of sodium; sulphates and carbonates of lime, magnesia, and potassa; and various chlorides, bromides, and iodides, are the principal saline ingredients.

The salt of the ocean is derived either from the washings of the land, or is dissolved out from the portions of the crust which are continually covered by its waters.

The ocean is salter in those parts where the evaporation exceeds the rainfall. Seas like the Mediterranean, which are connected with the ocean by narrow channels, and in which the evaporation is greater than the rainfall, are salter than the ocean. Others, like the Baltic, in which the rainfall exceeds the evaporation, are fresher than the ocean.

Most of the bed of the ocean is covered with a layer of dense water, at about the temperature of its maximum density.

The Pacific and Atlantic Oceans occupy about three-fourths of the entire water-area of the earth.

South of the southern extremities of South America, Africa, and Australia, the meridians of Cape Horn, Cape Agulhas, and South Cape in Tasmania, are assumed as the eastern boundaries of the Pacific, Atlantic, and Indian Oceans.

The articulation of land and water assumes four distinct forms: *Inland Seas, Border Seas, Gulfs and Bays, and Fiords. Inland Seas* characterize the *Atlantic; Border Seas,* the *Pacific; Gulfs and Bays,* the *Indian Ocean;* and *Fiords,* the *Atlantic* and *Pacific.*

The telegraphic plateau lies between Ireland and Newfoundland. Its average depth is about two miles.

The bottom of the ocean is not as much diversified as the surface of the land. Its plateaus and plains are believed to be much broader than are those of the land. The profound valleys of the ocean are called *deeps,* its shallow parts, *rises.*

The greatest depth of the ocean that has as yet been accurately sounded is about 5½ miles. It is probably deeper than this in some places.

Over extended areas, the floor of the ocean is uniformly covered with a deposit of fine calcareous mud or ooze, formed of the hard parts of the bodies of minute animalculæ.

The movements of the oceanic waters may be arranged under the three heads: waves, tides, and currents.

The height and velocity of a wave depend upon the force of the wind and the depth of the oceanic basin.

In ordinary wave motion, the water rises and falls, but does not move forward.

Tides are the periodical risings and fallings of the water, caused by the attraction of the sun and moon.

The rising of the water is called flood tide; the falling, ebb tide.

If the earth were uniformly covered with a layer of water, two high tides would occur simultaneously; one on the side of the earth directly under the sun or moon, the other on the side farthest from the sun or moon.

The tidal wave crosses the ocean from east to west, following the moon in the opposite direction to that in which the earth passes under it while rotating. Its progress is considerably retarded by the projections of the continents, and the shape of the oceanic beds. Had the moon no real motion around the earth, there would be two high and two low tides every twenty-four hours, or the high and low tides would be exactly six hours apart.

Spring Tides are caused by the combined attractions of the sun and moon on the same portions of the earth. *Neap tides* by their opposite attractions.

The parent tidal wave is considered as originating in the great water-area of the Pacific on the south.

Co-tidal lines are lines connecting places which have high tides at the same time.

When the progress of the tidal wave is retarded by the shelving coast of a continent, what the tide loses in speed, it gains in height. The highest tides, therefore, occur where the co-tidal lines are crowded together.

Bores, Races, and *Whirlpools* are tidal phenomena.

Oceanic currents are either temporary, periodical, or constant.

The heat of the sun and the rotation of the earth are the main causes of constant oceanic currents.

The following peculiarities characterize the constant currents in the three central oceans:

(1.) A flow in the equatorial regions from the east to the west;

(2.) A flow in extra-tropical regions from the west to the east;

(3.) A division of the eastwardly flowing extra-tropical waters in mid-ocean into two branches; one of which flows toward the poles, and the other toward the equator, where it merges into the equatorial currents.

The principal cause of constant ocean currents is the difference in the density of the equatorial and polar waters, produced by differences of temperature.

The cold, dense waters of the polar regions tend to mix with the warm, light waters of the equatorial regions along due north-and-south lines. This tendency to north and south direction is prevented by the following causes:

(1.) The rotation of the earth;
(2.) The position of the continents;
(3.) The direction of the winds;
(4.) The difference in the saltness of the water;
(5.) The inequality of the evaporation and rainfall.

In the Pacific, a counter-current crosses the ocean in the equatorial region, from west to east.

In the Indian Ocean, the directions of the currents are modified by the land masses, which surround the northern part of its bed.

In the northern hemispheres, the western borders of the oceans are colder than the eastern borders in the same latitude, because the former receive the polar currents and the latter the equatorial.

Currents moderate the extremes of climate, by carrying the warm equatorial waters to the poles, and the cold polar waters to the equator.

REVIEW QUESTIONS.

How much heavier is salt water than fresh water?

What is the freezing-point of ocean water?

Explain the origin of the saltness of the oceanic waters.

In the equatorial region, where is the water the colder, at the surface or near the bottom of the ocean?

How do the areas of the Pacific and Atlantic compare with each other in size? Of the Antarctic and Arctic?

Define inland sea; border sea; gulf or bay; fiord; give examples of each.

Define deeps; rises.

What, most probably, is the shape of the bed of the Atlantic? Of the Pacific? Of the Indian Ocean?

Describe the Telegraphic Plateau.

How does the greatest depth of the ocean compare with the greatest elevation of the land?

Upon what does the height of a wave depend? On what does its velocity depend?

What proof is there that during wave motion in deep water there is no continued onward motion of the water?

Distinguish between ebb and flood tides.

What proofs have we that tides are occasioned mainly by the attraction of the moon?

What are spring tides? Neap tides? During what phases of the moon do they each occur?

Why should the moon, which is so much smaller than the sun, exert a more powerful influence in producing tides?

Where does the parent tidal wave originate?

What are co-tidal lines?

Why does the tidal wave progress from east to west?

Explain the nature of the influence which the tidal wave exerts on the rotation of the earth.

In what parts of the ocean will unusually high tides occur? Why?

By what are races and whirlpools occasioned?

Distinguish between temporary, periodical, and constant oceanic currents.

Explain the origin of constant currents. How are the directions of constant currents affected by the rotation of the earth and the shapes of the continents?

What features of constant currents are common to each of the three central oceans?

On which side of the northern oceans do the polar currents flow? On which side of the southern oceans?

What are sargasso seas? How are they formed?

What effect is produced by ocean currents on the extremes of climate?

Of what value are ocean currents to navigation?

MAP QUESTIONS.

Point out, on the map of the river-systems, the inland seas of the Atlantic; of the Pacific; of the Indian Ocean.

Point out the border seas of the Atlantic; of the Pacific.

Point out the gulfs or bays of the Atlantic; of the Indian Ocean.

Point out the principal regions of fiords.

How many hours does it take the tidal wave to progress from Tasmania to the Cape of Good Hope? From Tasmania to Newfoundland? From Tasmania to the British Isles? (See map of the co-tidal lines.)

In what parts of the Atlantic does the tidal influence progress most rapidly?

If the velocity of any kind of wave motion in water increases with the depth of the basin, what parts of the Atlantic appear to be the deepest? What portions of the Pacific? What portions of the Indian Ocean?

Trace on the map of the ocean currents, the motion of the Antarctic currents in each of the three central oceans.

Where is the Cape Horn current? Is it hot or cold? What points of resemblance exist between the north and south equatorial currents in the Atlantic and Pacific Oceans?

Trace the progress of the Gulf Stream.

What points of resemblance exist between the Gulf Stream and the Japan current?

How far to the north-east do the waters of the Gulf Stream extend?

What distant shores are warmed by the waters of the Gulf Stream? By those of the Japan current?

Why do not the heated waters of the Gulf Stream exert a more powerful influence on the climate of the eastern sea-board of the United States?

Point out the principal cold currents; the principal warm currents.

Which currents would aid, and which would retard, the progress of a vessel in sailing from New York to San Francisco? From America to Europe? From America to India or Australia?

PART IV.

THE ATMOSPHERE.

We live at the bottom of a vast ocean of air, which, like the ocean of water, is subject to three general movements—waves, tides, and currents. By means of waves, its upper surface is heaved in huge mountain-like masses in one place, and hollowed out in deep valleys in another. By means of currents, circulatory movements are set up, which effect a constant interchange between the air of the equatorial and the polar regions. By means of tides, the depth of the atmosphere is increased in some places and decreased in others.

Of these three movements of the atmosphere, currents are of the greatest importance. Aërial currents, or winds, are similar to oceanic currents, but are more extensive and rapid, owing to the greater mobility of air.

By retaining and modifying the solar heat, absorbing and distributing moisture, supplying animals with oxygen and plants with carbonic acid, the atmosphere plays an important part in the economy of the earth.

Meteorology is the science which treats of the atmosphere and its phenomena.

SECTION I.

THE ATMOSPHERE.

CHAPTER I.

General Properties of the Atmosphere.

227. Composition.—The atmosphere is a mechanical mixture of *nitrogen* and *oxygen*, in the proportion, by weight, of nearly 77 per cent. of nitrogen to 23 per cent. of oxygen. To these must be added *a nearly constant quantity of carbonic acid*, about 5 or 6 parts in every 10,000 parts of air, or about a cubic inch of carbonic acid to every cubic foot of air, and *a very variable pro-*

portion of watery vapor. The gaseous ingredients, though of different densities, are found in the same relative proportions at all heights, owing to a property of gases called *diffusion.*

The oxygen and carbonic acid are the most important of the gaseous constituents. Oxygen supports combustion and respiration, and is thus necessary to the existence of *animal life.* Carbonic acid, composed of carbon and oxygen, is the source from which vegetation derives its *woody fibre,* and is thus necessary to the existence of *plant life.* In respiration, animals take in oxygen and give out carbonic acid; in sunlight, plants take in carbonic acid and give out oxygen. In this way the relative proportions of the *substances necessary to the existence of animal and plant life are kept nearly constant.*

228. Elasticity.—The atmosphere is eminently elastic; that is, when compressed, or made to occupy a smaller volume, it will regain its original volume on the removal of the pressure. Air also expands when heated and contracts when cooled.

229. Pressure.—So evenly does the atmosphere press on all sides of objects that it was long before it was discovered that air possesses weight. The discovery was made by Torricelli, an Italian philosopher and pupil of the famous Galileo. The instrument Torricelli employed is called a *Barometer.*

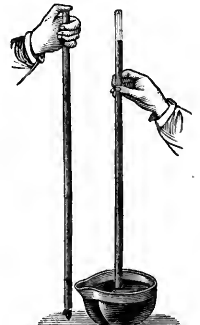


Fig. 79. Barometer.

230. The Barometer.—The principle of the barometer is as follows: A glass tube, about 33 inches in length, is closed at one end and filled with pure mercury. Placing a finger over the open end, the tube is reversed and dipped below the surface of mercury in a cup or other vessel. On removing the finger, a column of mercury remains in the tube, being sustained there by the pressure of the atmosphere. Near the sea-level this column is about 30 inches high; on mountains it is much lower; in all cases, the weight of the mercurial column being equal to that of an equally thick column of air, extending from the level of the reservoir to the top of the atmosphere.

Any variation in the pressure of the atmosphere is marked by a corresponding variation in the height of the mercury in the barometer, the column rising with increased, and falling with diminished, pressure.

The entire atmosphere presses on the earth with the same weight as would a layer of mercury about 30 inches in depth. A column of mercury 30 inches high, and one square inch in area of cross section, weighs about 15 pounds. *Therefore, the pressure which the atmosphere exerts on the earth's surface, at the level of the sea, is equal to about 15 pounds for every square inch of surface.* The entire weight of the atmosphere, in pounds, is equal to 15 times the number of square inches in the earth's surface.

The atmospheric pressure is not uniform on all parts of the earth at the same level. From a few degrees beyond the equator the pressure increases in each hemisphere up to about lat. 35°, where it reaches its maximum, decreasing in the northern hemisphere to lat. 65°, when it again increases toward the poles.

231. Height of the Atmosphere.—If the air were everywhere of the same density, its height could be easily calculated; but, on account of its elasticity, the lower layers are denser than the others, because they have to bear the weight of those above them. The density must, therefore, rapidly diminish as we ascend.

If by pressure on a gas we diminish its volume one-half, its density will be doubled; conversely, if the density be diminished one-half, the volume will be doubled. The following table, calculated from the law of increase in volume with diminished pressure, gives the barometric height, the volume, and the density of the air at different elevations above the sea. The elevation of 3.4 miles is the result of observation; the other distances are estimated.

Barometric Height in Inches.	Vol. of Given Weight of Air.	Density.	Estimated Distance ab. Sea, in Miles.
30.00	1	1	0.0
15.00	2	$\frac{1}{2}$	3.4
7.50	4	$\frac{1}{4}$	6.8
3.75	8	$\frac{1}{8}$	10.2
1.87	16	$\frac{1}{16}$	13.6
.93	32	$\frac{1}{32}$	17.0

It appears from the above table that by far the greater part of the air by weight lies within a few miles of the surface, nearly three-fourths being below the level of the summits of the highest mountain-ranges.

The height of the upper limit of the atmosphere has been variously estimated. Calculations based upon the diminution of pressure with the height, place it at from 45 to 50 miles above the level of the sea; others, based on the duration of twilight, place it at distances varying from 35 to 200 miles.

The form of the atmosphere is that of an oblate spheroid, the oblateness of which is greater than that of the earth.

By carefully observing the decrease in pressure with the elevation, at different altitudes, and making proper corrections, the heights of mountains can be readily determined by the barometer. The measurement of heights by the barometer, or similar means, is called *Hypsometry*.

CHAPTER II.

Climate.

232. The Climate of a country is the condition of its atmosphere as regards *heat or cold.*

The climate of a country also embraces the condition of the air as regards moisture or dryness, and healthiness or unhealthiness, which are dependent on the temperature.

233. Temperature.—The temperature of the atmosphere is determined by means of an instrument called a thermometer.

The thermometer consists of a glass tube of very fine bore, furnished at one end with a bulb. The tube is carefully dried and the bulb filled with pure mercury and heated in the flame of a spirit-lamp; the mercury expands, and, filling the fine capillary tube, a portion runs out from the open end, thus effectually expelling the air. A blowpipe flame is then directed against the open end and the tube hermetically sealed. As the bulb cools, the mercury contracts, and leaves a vacuum in the upper part of the tube. The instrument will now indicate changes in temperature; for, whenever the bulb grows warmer, the column of mercury expands and rises; and when it grows colder, it contracts and falls.

In order to compare these changes of level they are referred to certain *fixed or standard points: the freezing- and boiling-points* of pure water. These are obtained by marking the respective heights to which the mercury rises when the thermometer is plunged into melting ice and into the steam escaping from boiling water. In *Fahrenheit's scale* the freezing-point is placed at 32°, the boiling-point at 212°, and the space between these two points divided into 180, (212 —32) equal parts, called degrees. In the *Centigrade scale* the freezing- and boiling-points are respectively 0° and 100°. Fahrenheit's degrees are represented by an F., thus, 212° F.; Centigrade's by a C., as 100° C.

234. Astronomical and Physical Climates.—*Astronomical climate* is that which would result were the earth's surface entirely uniform and of but one kind: all land or all water.

Physical climate is that which actually exists.

Since the physical climate is only a modification of the astronomical, we shall briefly review the causes which tend to produce a regular decrease in temperature from the equator to the poles.

Astronomical Climate.—The sun is practically the only source of the earth's heat. On account of the earth's spherical shape, those portions of the surface are most powerfully heated which receive the vertical rays, and these are confined to a zone reaching 23° 27′ on each side of the equator. Beyond these the rays fall with an obliquity which increases as we approach the poles.

235. Causes of the greater heating power of the vertical rays of the sun than of the oblique rays.

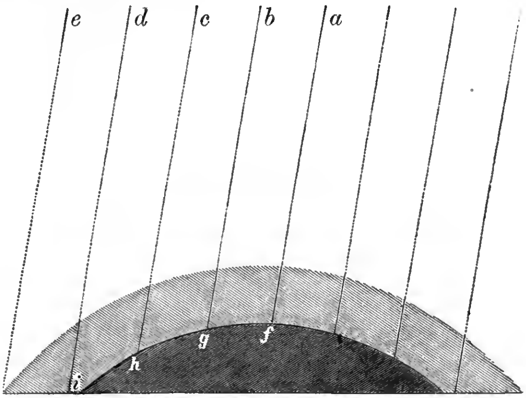


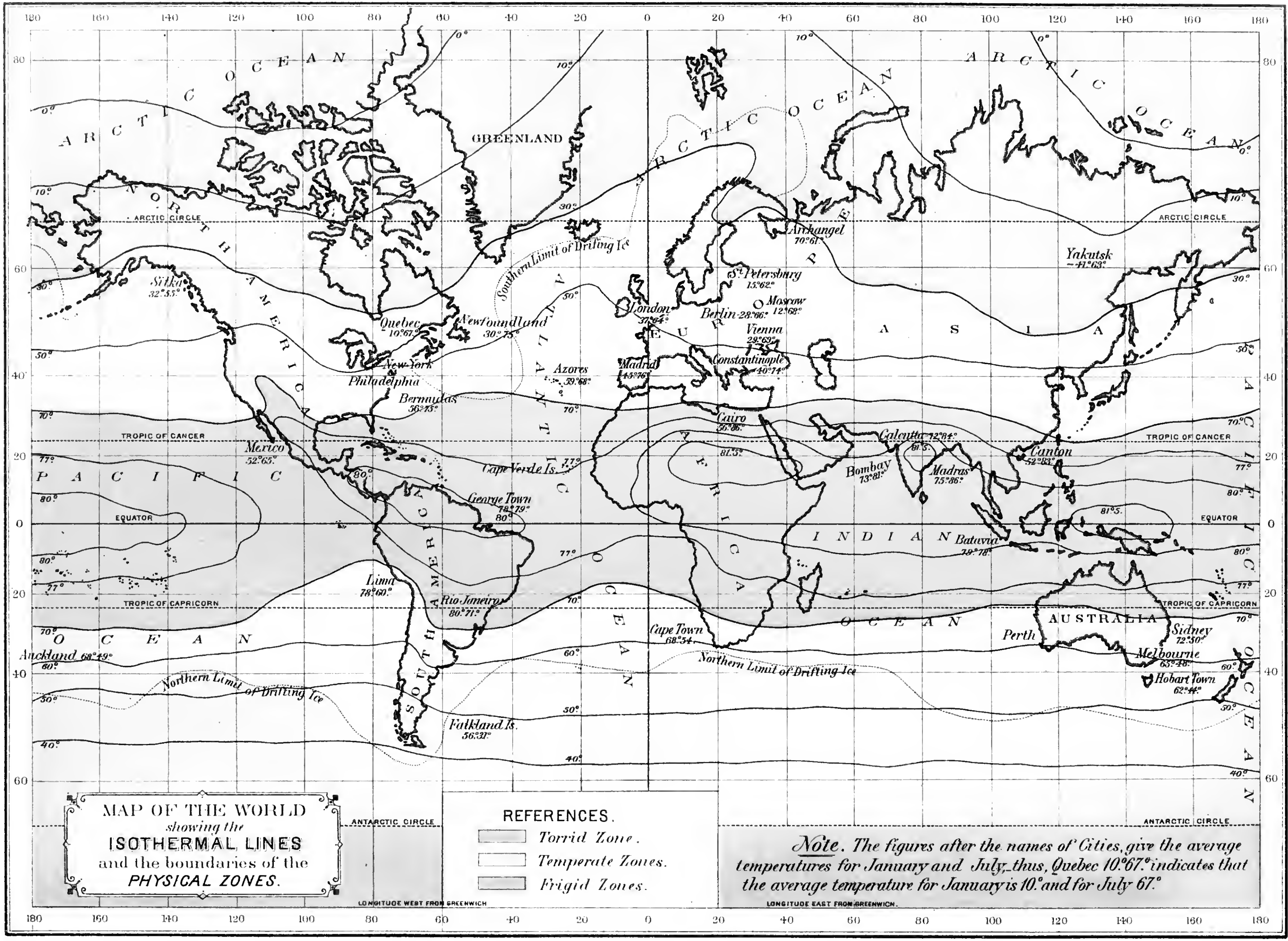
Fig. 80. Causes of the Greater Heating Power of the Vertical than of the Oblique Rays.

(1.) **The vertical rays are spread over a smaller area.** Equal areas of the sun's surface give off equal quantities of heat. If, therefore, the bundle of rays *a b*, and *c d*, come from equal areas, the amounts of heat they emit will be equal; but while the heat given off from *a b*, the more vertical rays, is spread over the earth's surface from *f*, to *g*, that from *c d*, is spread over the greater area *h i*; the area *f g*, therefore, which receives the more vertical rays, is much warmer than *h i*, where the obliquity is greater.

(2.) **The vertical rays pass through a thinner layer of air.** Only a part of the sun's heat reaches the surface of the earth; about 28 per cent. of the vertical rays are absorbed during their passage through the atmosphere. The amount of this absorption must increase as the length of path increases. In the figure, the light shading represents the atmosphere. It is clear that the oblique rays pass through a thicker stratum of air than the more direct ones, and, therefore, are deprived of a greater amount of heat.

According to Laplace, the thickness of the stratum of air traversed by the rays when the sun is at the horizon is 35.5 times greater than when it is directly overhead. A similar absorption of light affects the comparative brightness of daylight in different latitudes.

(3.) **The vertical rays strike more directly, and, therefore, produce more heat.** The heating


MAP OF THE WORLD
showing the
ISOTHERMAL LINES
and the boundaries of the
PHYSICAL ZONES.
REFERENCES.
Torrid Zone.
Temperate Zones.
Frigid Zones.
Note. The figures after the names of Cities, give the average temperatures for January and July, thus, Quebec 10°67° indicates that the average temperature for January is 10° and for July 67°.
LONGITUDE WEST FROM GREENWICH
LONGITUDE EAST FROM GREENWICH
ARCTIC OCEAN
PACIFIC OCEAN
ATLANTIC OCEAN
INDIAN OCEAN
NORTH AMERICA
SOUTH AMERICA
EUROPE
ASIA
AFRICA
AUSTRALIA
GREENLAND
ARCTIC CIRCLE
TROPIC OF CANCER
EQUATOR
TROPIC OF CAPRICORN
ANTARCTIC CIRCLE
Southern Limit of Drifting Ice
Northern Limit of Drifting Ice
Sitka 32°55°
Quebec 10°67°
Newfoundland 30°75°
New York
Philadelphia
Bermudas 56°75°
Azores 59°68°
Mexico 52°65°
Cape Verde Is.
George Town 78°79°
Lima 78°60°
Rio Janeiro 80°71°
Falkland Is. 56°31°
Auckland 68°49°
London 37°64°
Madrid 45°76°
Berlin 28°66°
St. Petersburg 15°62°
Moscow 12°68°
Vienna 29°69°
Constantinople 40°74°
Archangel 70°61°
Cairo 56°86°
Cape Town 68°54°
Calcutta 72°84°
Bombay 73°81°
Madras 75°86°
Batavia 79°78°
Canton 52°83°
Yakutsk −41°63°
Perth
Sidney 72°50°
Melbourne 65°48°
Hobart Town 62°44°

power of the more nearly vertical rays is greater than that of the rays which strike obliquely.

236. Variations in Temperature.—The differences in the heating power of the vertical and oblique rays of the sun cause the temperature of the earth's surface to decrease gradually from the equator toward the poles. The differences of temperature thus effected are further increased by the difference in the length of daylight and darkness. While the sun is shining on any part of the earth the air is gaining heat; when it is not shining the air is losing heat. When the length of daylight exceeds that of the darkness, the gain exceeds the loss; when the darkness exceeds the daylight, the loss exceeds the gain.

The excessively low temperatures that would result from the oblique rays in high latitudes are prevented by the great length of daylight during the short summers, thus allowing the sun to continue heating the surface during longer periods. The warmest part of the day in high latitudes sometimes equals that in the equatorial regions. During the long winters, however, the continued loss of heat makes the cold intense.

Hence in the tropics we find a continual summer; in the temperate zones, a summer and winter of nearly equal length; and in the polar zones, short, hot summers, followed by long, intensely cold winters.

The true temperature of the air is ascertained by hanging a thermometer a few feet above the ground, so as to be shielded from the direct rays of the sun, and yet be in free contact on all sides with the air.

237. Manner in which the Atmosphere receives its Heat from the Sun.—The atmosphere receives its heat from the sun—

(1.) **Directly.** As the sun's rays pass through the air, about 28 per cent. of the vertical rays are directly absorbed, thus heating the air. The remainder pass on and either heat the earth, or are reflected from its surface.

(2.) **From the heated earth.** The sun's rays heat the earth and the heated earth heats the air. It does this in three ways:

(*a.*) By the air coming in contact with the heated earth.

(*b.*) By the heated earth radiating its heat, or sending it out through the air in all directions.

After the sun's heat has been absorbed by the earth and radiated from it, a change occurs which renders the rays much more readily absorbed by the air.

(*c.*) By the heat being reflected from the earth and again sent through the air. But little heat is imparted to the air in this way.

It is mainly the aqueous vapor the atmosphere contains that absorbs the sun's heat. Dry air allows the greater part of the heat to pass through it; therefore *variations in the quantity of vapor in the air* must necessarily produce corresponding variations in the distribution of heat.

238. Isothermal Lines are lines connecting places on the earth which have the same mean temperature.

The Mean Daily Temperature of a place is obtained by taking the average of its temperature during twenty-four consecutive hours.

The Mean Annual Temperature of a place is the average of its mean daily temperature throughout the year.

If the *physical climate* were the same as the astronomical, the *isothermal lines* would coincide with the parallels of latitude.

An inspection of the map of the isothermal lines shows that their deviations from the parallels, though well marked in all parts of the earth, *are greatest in the northern hemisphere.* Wherever, from any cause, *the mean temperature of a place is higher, the isothermal lines are found nearer the poles; when lower, nearer the equator.* The former effects are noticed particularly in portions of the ocean traversed by warm currents; the latter, in crossing portions of the ocean traversed by cold currents. In the map of the isothermal lines the influence of elevation is removed by adding 1° for every 1000 feet of elevation.

239. Physical Zones.—**The Physical Torrid Zone** lies on both sides of the equator, between the annual isotherms of 70° Fahr.

The Physical Temperate Zones lie north and south of the Physical Torrid Zone, between the annual isotherms of 70° and 30° Fahr.

The Physical Frigid Zones lie north and south of the Physical Temperate Zones, from the annual isotherms of 30° Fahr. to the poles.

The greatest mean annual temperature in the eastern hemisphere is found in portions of North Central Africa, and in Arabia near the Red Sea, in the southern part of Hindostan, and in the northern part of New Guinea and the neighboring islands; in the western hemisphere, in the northern parts of South America and in Central America.

240. Modifiers of Climate.—The principal causes which prevent the isothermal lines from coinciding with the parallels of latitude are:

(1.) **The Distribution of the Land and Water Areas.**—Land heats or cools rapidly, absorbing or emitting but little heat. This is because the land has a small capacity for heat, and also because the heat passes through but a comparatively thin layer. Therefore, a comparatively short exposure of land to heat produces a high temperature, and a comparatively short exposure to cooling, a low temperature. Water heats or cools slowly, absorbing or emitting large quantities of heat. This is because water has a great capacity for heat. The heat penetrates a comparatively deep layer, and then, too, as soon as slightly heated, the warm water is replaced by cooler water. Therefore, the water can be exposed to either long heating or long cooling without growing very hot or very cold. Hence, the land is subject to *great and sudden changes of temperature;* the water, to *small and gradual changes.*

Places situated near the sea have, therefore, a more equable, uniform climate than those in the same latitude in the interior of the continent. The former are said to have an *oceanic climate;* the latter, a *continental climate.*

In the polar regions, a preponderance of moderately elevated land areas causes a colder climate than an equal area of water, because land loses heat more rapidly than water.

In the tropics, a preponderance of land areas causes a warmer climate than an equal area of ~~land~~ water, because land gains heat more rapidly than water.

(2.) **The Distribution of the Relief Forms of the Land Masses.**

(1.) **Elevation.**—The temperature of the atmosphere rapidly decreases with the elevation. The decrease is about 3° Fahr. for every 1000 feet.

The increased cold is caused as follows:

(1.) Since the air receives so much of its heat indirectly from the earth's surface, the farther we go upward from the surface, the colder it grows.

(2.) In the upper regions of the atmosphere the *decreased density and humidity of the air* prevent it from absorbing either the direct rays of the sun, or those reflected or radiated from the earth. The effect of elevation is so powerful that on the sides of high tropical mountains the same changes occur in the vegetation that are observed in passing from the equator to the poles.

(2.) **Direction of the Slopes.**—That slope of an elevation which receives the sun's rays in a direction more nearly vertical than others, will be the warmest.

In the northern hemisphere the southern slope of a hill is warmer in winter than the northern slope, because it receives the rays more vertically.

(3.) **Position of the Mountain-Ranges.**—A mountain-range will make the country near it warmer if the wind from which it shields it is cold; it will make it colder if such wind is warm.

The position of the mountain-ranges of a country also greatly affects the distribution of its rainfall. Thus, the tropical Andes are well watered and fertile on their eastern slopes, but dry and barren on their western. The prevailing moist trade winds, forced to ascend the slopes, deposit all their moisture on them in abundant showers, and are dry and vaporless when they reach the other side.

(4.) **Nature of the Surface.**—The temperature of a tract of land is greatly affected by the nature of its surface. If covered with abundant vegetation, like a forest, or if wet and marshy, its surface heats and cools slowly, and has a comparatively uniform temperature; but if destitute of vegetation, and dry, sandy, or rocky, it both heats and cools rapidly, and is subject to great extremes of temperature.

(3.) **Distribution of Winds and Moisture.**—The principal action of the winds, and their accompanying moisture, *is to moderate the extremes of temperature* by the constant interchange between the heat of the equatorial and the cold of the polar regions. Both wind and vapor absorb and render latent large quantities of heat in the equatorial regions, and give it out, in higher latitudes, on cooling. In cold countries the climate is rendered considerably warmer by the immense quantity of heat thus emitted by the condensed vapor.

(4.) **Ocean Currents.**—Since the warm waters move to the polar regions, and the cold waters to the equatorial regions, the general effect of ocean currents on climate is to reduce the extremes of temperature.

The combined effects of the action of the *winds, moisture, and ocean currents* are seen in the *northern continents, whose western shores*, under the influence of the prevailing south-westerly winds, copious rains, and tropical currents, are considerably warmer than the eastern shores in the same latitude.

The coasts of Great Britain are warm and fertile, while Labrador, in the same latitude, is cold and sterile. The island of Sitka, in the Pacific, is warmer than Kamtchatka from similar causes.

CHAPTER III.

The Winds.

241. Origin of Winds.—Winds are masses of air in motion. They resemble currents in the ocean, and result from the same causes—differences of density caused by differences of temperature.

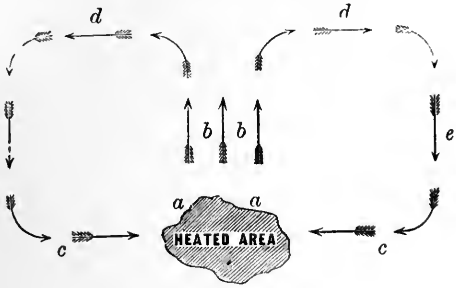


Fig. 81. Origin of Winds.

The equilibrium of the atmosphere is disturbed by differences of temperature as follows: When any area becomes heated, as at *a a*, Fig. 81, the air over it, expanding and becoming lighter, is pressed upward by the colder air which rushes in from all sides. Thus result the following currents: *ascending currents, b b, over the heated area; lateral, surface currents, c c, from all sides toward the heated area; upper currents, d d, from the heated area; and descending currents, e e.* It is the lateral currents which flow toward or from the heated area that are felt mainly as winds. The ascending currents rise until they reach a stratum of air of nearly the same density as their own, and then spread laterally in all directions toward the areas where the air has been rarefied by the movements of the lateral surface currents, until they finally descend, and recommence their motion toward the heated area. These circulatory motions continue as long as the heated area remains warmer than surrounding regions.

In speaking of winds, reference is always made to the surface currents, unless otherwise stated.

242. Origin of the Atmospheric Circulation.—The hottest portions of the earth are, in general, within the tropics; hence in the equatorial regions ascending currents continually prevail. To supply the partial vacuum so created, lateral surface currents blow in toward the equator from the poles, while the ascending currents, after reaching a certain elevation, blow as upper currents toward the poles. Thus result currents by which the entire mass of the atmosphere is kept in constant circulation, and an interchange effected between the air of the equator and the poles.

The most important of these currents are the following:

(1.) *Polar currents, or the lateral surface currents,* which flow from the poles to the equator; and

(2.) *Equatorial currents, or the upper currents,* which flow from the equator toward the poles.

It will be noticed that wherever the surface wind blows in any given direction, the upper wind blows in the opposite direction.

In several instances the ashes of volcanoes have been carried great distances in directions *opposite to that in which the surface wind was blowing.* The smoke from tall chimneys at first takes the direction of the surface wind, but rising, is soon carried in the opposite direction by the upper currents. The clouds are often seen moving in a direction opposite to that indicated by vanes placed on the tops of the houses.

A current of air is named according to *the direction from which it comes;* a current of water, according to *the direction in which it is going.* Thus, a north-east wind comes from the north-east; a north-east current of water goes toward the north-east.

243. Effect of the Earth's Rotation on the Direction of the Wind.—Were the earth at rest, the equatorial and polar currents would blow due north and south in each hemisphere; but by the rotation of the earth they are turned out of their course in a manner similar to the oceanic currents already studied.

The polar currents, as they approach the equator, where the axial velocity toward the east is greater, are left behind by the more rapidly moving earth, and thus come, as shown in Fig. 83, from the north-east in the northern hemisphere, and from the south-east in the southern.

The equatorial currents, under the influence of the earth's eastward motion, are carried toward the east as they approach the poles, and thus come, as shown in Fig. 83, from the south-west in the northern hemisphere, and from the north-west in the southern.

Wherever the polar winds prevail, their direction, when unaffected by local disturbances, *will be north-east in the northern hemisphere, and south-east in the southern.* Near the equator their direction is nearly due east.

Wherever the equatorial currents prevail, their direction *will be south-west in the northern hemisphere, and north-west in the southern.*

In Fig. 82, the equatorial currents are represented *as continuing* to either pole as upper currents, and the polar winds as surface currents to the equator. If this were so, constant north-easterly winds would prevail in the northern hemi-

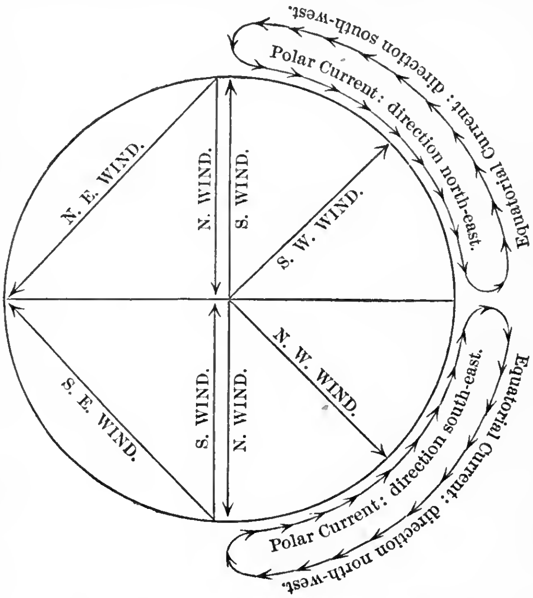


Fig. 82. Direction of Wind as Affected by Rotation.

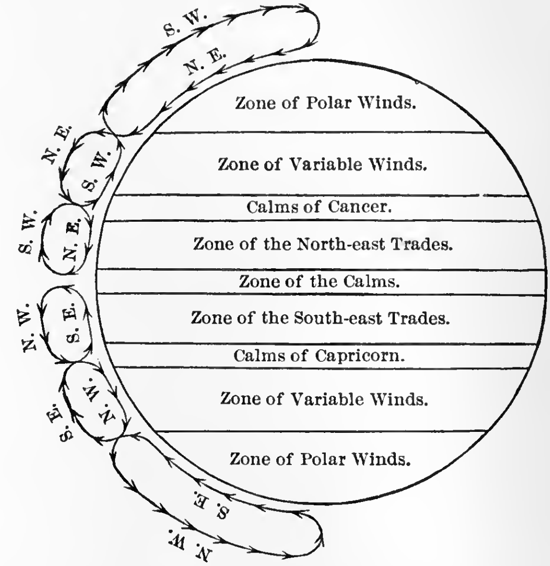


Fig. 83. Interchange of the Equatorial and Polar Currents. Wind Zones.

sphere, and constant south-easterly winds in the southern. Several causes, however, exist to prevent this simple circulation of the air between the equatorial and polar regions.

The equatorial currents do not continue as upper currents all the way to the poles, but fall and become surface currents, replacing the polar winds, which rise and continue for a while toward the equator as upper currents.

244. Causes of Interchange of Surface and Upper Currents.—The causes which produce this shifting of the equatorial and polar currents are:

(1.) The equatorial currents become cold—

(*a.*) By the cold of elevation;

(*b.*) By expansion;

(*c.*) By change of latitude.

The equatorial currents therefore fall and are replaced by the polar currents, which have been gradually growing warmer by continuing near the surface of the earth.

(2.) As the equatorial currents approach the poles they have a smaller area over which to spread, and, being thereby compressed, are caused to descend and become surface currents.

This interchange between the equatorial and polar currents takes place at about lat. 30°. It varies, however, with the position of the sun, moving toward the poles when the sun is nearly overhead, and toward the equator when the sun is in the other hemisphere.

The interchange in the position of the equatorial and polar currents is represented in Fig. 83.

As the equatorial currrents fall, they divide, part going to the poles, and part returning to the equator.

The general system of the aërial circulation thus indicated is more regular over the oceans than over the land. Over the continents the greater heat of the land during summer causes a general tendency of the wind to blow toward the land; similarly, the greater cold of the land during winter causes a tendency of the wind to blow toward the sea.

245. Classification of Winds.—Winds are divided into three classes:

(1.) *Constant*, or those whose direction remains the same throughout the year.

(2.) *Periodical*, or those which, for regular periods, blow alternately in opposite directions.

(3.) *Variable*, or those which blow in any direction.

246. Wind Zones.—The principal wind zones are the zone of calms, the zones of the trades, the zones of the calms of Cancer and Capricorn, the zones of the variable winds, and the zones of the polar winds.

Zone of Calms.—In parts of the ocean near the equator the ascending currents are sufficiently powerful to neutralize entirely the inblowing polar currents, and thus produce a calm, which, however, is liable at any moment to be disturbed by powerful winds. The boundaries of the zone vary with the season; they extend from about 2° to 11° north latitude.

Zones of the Trades.—From the limits of the zone of calms to about 30° on each side of the equator the polar currents blow with great steadiness throughout the year. The constancy in their direction has caused these winds to be named "*trade winds*," from their great value to commerce. *Their direction is north-east in the northern hemisphere, and south-east in the southern.*

Zones of the Calms of Cancer and Capricorn.—Between the zones of the trades and the variables, where the interchange takes place between the equatorial and polar currents, zones of calms occur. Their boundaries are not well defined, and are dependent on the position of the sun.

Zones of the Variable Winds.—Beyond the limits of the preceding zones to near the latitude of the polar circles, the equatorial and polar currents alternately prevail. Here the equatorial and polar currents are continually striving for the mastery, sometimes one and sometimes the other becoming the surface current. During these conflicts the wind may blow from any quarter; but when either current is once established it often continues constant for some days. This is especially the case over the ocean, where the modifying influences are less marked.

Though the winds in these zones are variable, still two directions predominate: south-west and north-east in the northern hemisphere, and north-west and south-east in the southern. Westerly winds, however, occur the most frequently in nearly all parts of these zones.

The equatorial currents are sometimes called the *Return Trades*, or the *Anti-trades*, because they blow in the opposite direction to the trades.

Between about lat. 25° and 40°, N. and S., over parts of the ocean, the winds are nearly periodical, blowing during the hotter portions of the year in each hemisphere from the poles, and during the remainder of the year from the equator. This zone is often called the Zone of the Subtropical winds.

Polar. Zones.—From the limits of the zones of the variables to the poles, there are regions of prevailing polar winds. These winds are most frequently north-east in the northern hemisphere, and south-east in the southern.

247. Dove's Law of the Rotation of the Winds.—The equatorial and polar currents usually displace each other, and become surface winds in a regular order, first discovered by Prof. Dove of Berlin.

In the northern hemisphere, before the polar current is permanently established from the north-east, the wind blows in regular order from the *west, north-west, and north.* The displacement of the polar by the equatorial currents occurs in the opposite direction: from the *east, south-east, and south,* before the general *south-west* current is permanently established.

In the southern hemisphere these motions are reversed.

This rotation of the winds, together with the effects produced on the thermometer and barometer, is indicated in the following diagram. Since the equatorial currents are warm, moist, and light, when they prevail the thermometer rises and the barometer falls. On the establishment of the polar currents, however, the thermometer falls and the barometer rises.

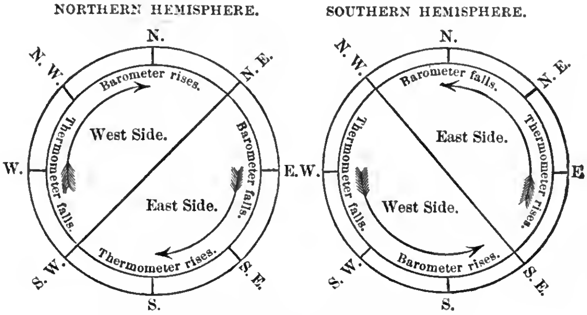


Fig. 84. Rotation of the Winds (after Dove).

The "*warm waves*" of the zones of the variable winds are caused by the prevalence of the equatorial currents. Similarly, the "*cold waves*" are caused by the prevalence of the polar currents.

248. Land and Sea Breezes.—During the day the land near the coast becomes warmer than the sea. An ascending current, therefore, rises over the land, and a breeze, called the *sea breeze,* sets in from the sea. At night the land, from its more rapid cooling, soon becomes colder than the water; the ascending current then rises from the

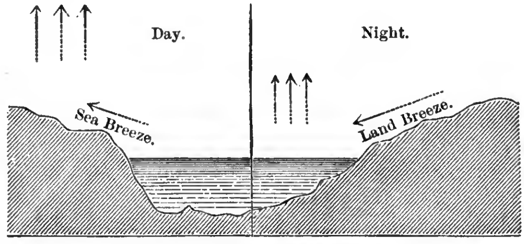
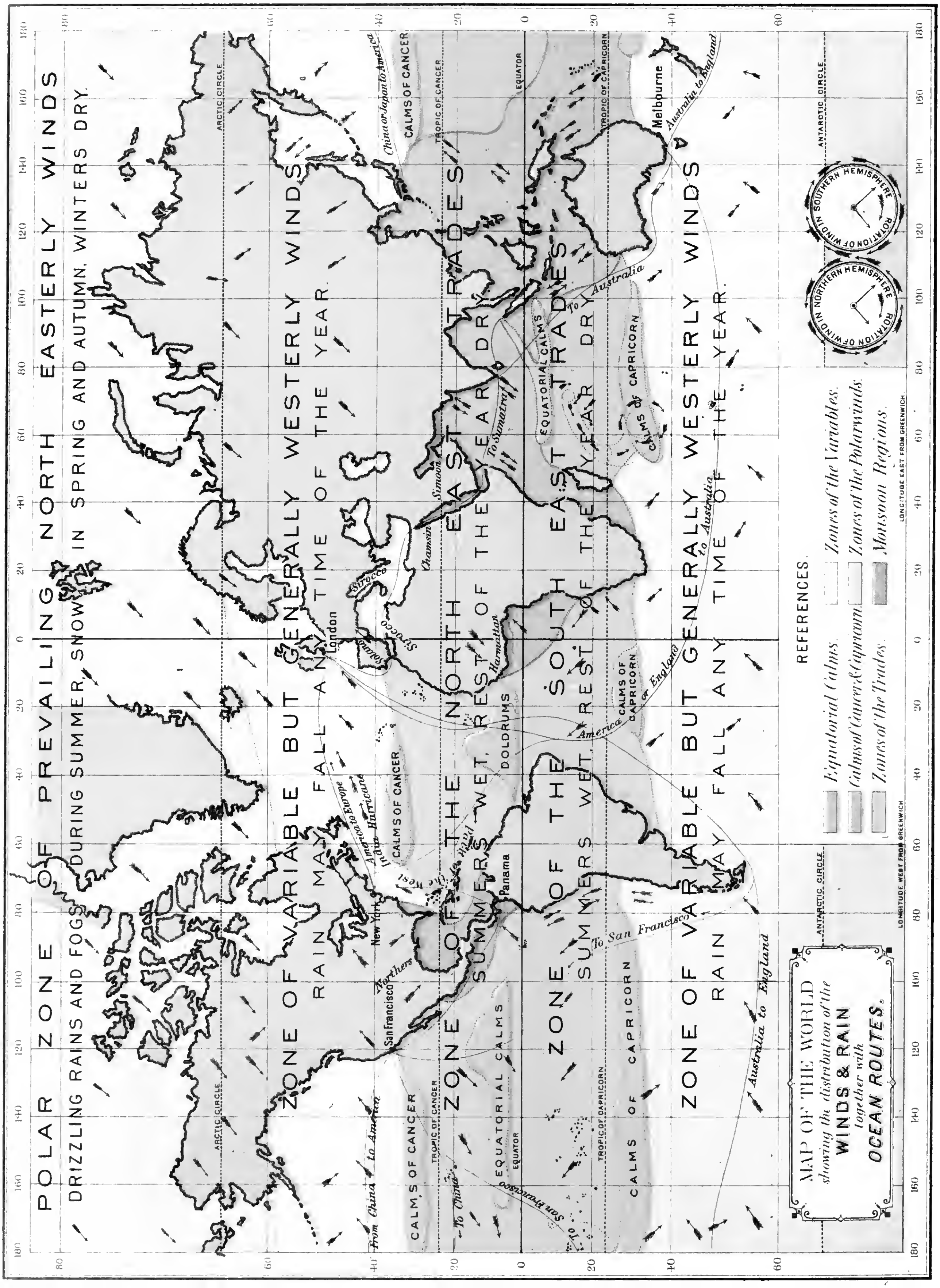


Fig. 85. Land and Sea Breezes.

water, and a breeze, called the *land breeze,* sets in from the land. The strength of these winds depends upon the difference in the temperature of the land and water; they are, therefore, best defined in the tropical and extra-tropical regions, though they may occur in higher latitudes during the hottest parts of the year. Land and sea breezes are periodical winds.

249. Monsoons are periodical winds, which during part of the year blow with great regularity in one direction, and during the remainder of the


POLAR ZONE OF PREVAILING NORTH EASTERLY WINDS
DRIZZLING RAINS AND FOGS DURING SUMMER, SNOW IN SPRING AND AUTUMN, WINTERS DRY.
ZONE OF VARIABLE BUT GENERALLY WESTERLY WINDS
RAIN MAY FALL ANY TIME OF THE YEAR.
ZONE OF THE NORTH EAST TRADES
SUMMERS WET, REST OF THE YEAR DRY.
ZONE OF THE SOUTH EAST TRADES
SUMMERS WET, REST OF THE YEAR DRY.
ZONE OF VARIABLE BUT GENERALLY WESTERLY WINDS
RAIN MAY FALL ANY TIME OF THE YEAR.
ARCTIC CIRCLE
TROPIC OF CANCER
EQUATOR
TROPIC OF CAPRICORN
ANTARCTIC CIRCLE
CALMS OF CANCER
EQUATORIAL CALMS
CALMS OF CAPRICORN
DOLDRUMS
London
New York
San Francisco
Panama
Melbourne
Northers
West India Hurricane
Sirocco
Solano
Harmattan
Chamsin
Simoon
To Sumatra
To Australia
America to Europe
China or Japan to America
From China to America
To China
To San Francisco
Australia to England
America or England
REFERENCES.
Equatorial Calms.
Calms of Cancer & Capricorn.
Zones of the Trades.
Zones of the Variables.
Zones of the Polarwinds.
Monsoon Regions.
ROTATION OF WIND IN NORTHERN HEMISPHERE
ROTATION OF WIND IN SOUTHERN HEMISPHERE
LONGITUDE WEST FROM GREENWICH
LONGITUDE EAST FROM GREENWICH
MAP OF THE WORLD
showing the distribution of the
WINDS & RAIN
together with
OCEAN ROUTES.

year in the opposite direction. They are in reality huge land and sea breezes, caused by the difference in temperature between the warmer and colder halves of the year. They occur mainly in the regions of the trades, and are in reality trade winds which have been turned out of their course by the unequal heating of land and water.

During winter, in either hemisphere, the oceans, being warmer than the land, cause a greater regularity in the *trades;* but during summer, the tropical continents become intensely heated, and their powerful ascending currents cause the equatorial currents to blow toward the heated areas as surface winds, and thus displace the trades. The interval between the two monsoons is generally characterized by calms, suddenly followed by furious gales, that may blow from any quarter.

250. Monsoon Regions.—There are three well-marked regions of monsoons—the Indian Ocean, the Gulf of Guinea, and the Mexican Gulf and Caribbean Sea. The first is the largest and most distinctly marked.

Monsoons of the Indian Ocean.—Here the trades are deflected by the overheating of the continents of Asia, Africa, and Australia.

In the northern hemisphere the north-east trades prevail with great regularity over the Indian Ocean during the cooler half of the year: from October to April, but during the warmer half: from April to October, the heated Asiatic continent deflects the trades, and the equatorial currents prevail from the south-west. The same winds also prevail south of the equator, on the western border of the ocean, along the eastern coast of Africa as far south as Madagascar.

In the southern hemisphere, in the south-eastern portion of the ocean, the south-east trade is similarly deflected by the Australian continent. Here the winds blow south-east during the southern winter, and north-west during its summer.

Monsoons of the Gulf of Guinea.—Here the north-east trades are deflected by the intensely heated continent of Africa. The south-west summer monsoon blows over the land as far inland as the Kong Mountains.

Monsoons of the Mexican Gulf and Caribbean Sea.—In this region the north-east trade winds are deflected by the overheating of the Mississippi Valley. *The Northers* of Texas, which are cold winds blowing for a few days at a time over the Texan and Mexican plains, may be considered as connected with the winter monsoons.

Besides the preceding well-marked regions, nearly all the coasts of the continents in and near the tropics have small monsoon regions, as, for example, the western coasts of Mexico, the eastern and western coasts of South America, and the western and northern coasts of Africa.

251. Desert Winds.—The rapid heating and cooling of deserts make them great disturbers of the regular system of winds. Currents alternately blow *toward and from* the heated area. The latter are intensely hot and dry.

The Etesian Winds.—During summer the barren soil of the Desert of Sahara, becoming intensely heated, causes strong north-east winds to blow from the north over the Mediterranean Sea. These are called the Etesian winds, and continue from July to September; they are strongest during the daytime.

Hot Desert Winds.—From the Sahara a periodical wind, called the *Harmattan,* blows *on the south-west,* over the coasts of Guinea; *on the north, the Solano* blows over Spain, and the *Sirocco* blows over Southern Italy and Sicily. Though somewhat tempered during their passage across the Mediterranean, these winds are still exceedingly hot and oppressive.

From the deserts of Nubia and Arabia intensely hot, dry winds blow in all directions over the coasts of Arabia, Nubia, Persia, and Syria. These winds are known under the general name of the *simoom* or *samiel.* From their high temperature and the absence of moisture, they often cause death from nervous exhaustion.

During the prevalence of the simoom, particles of fine sand are carried into the atmosphere and obscure the light of the sun. Becoming intensely heated, these particles, by their radiation, increase the temperature of the air, which sometimes rises as high as 120° or 130° Fahr. When powerful winds prevail, dense clouds of sand are carried about in the atmosphere, producing the so-called sand storms. The sand-drifts which are thus formed constantly change their position.

Fig. 86. Sand Storm in the Desert.

The Khamsin blows at irregular intervals over Egypt from the south; but when established, generally continues for fifty days. It is intensely hot and dry, like the simoom, and is loaded with fine sand.

252. Mountain Winds.—During the day the elevated slopes of mountains heat the air over them hotter than at corresponding elevations over the valleys. Currents, therefore, *ascend the valleys toward the mountains during the day.* During the night, however, the air near the summits becomes colder than that near the base. Currents, therefore, *descend the valleys from the mountains during the night.*

CHAPTER IV.

Storms.

253. Storms are violent disturbances of the ordinary equilibrium of the atmosphere by wind, rain, snow, hail, or thunder and lightning.

During storms the wind varies in velocity from that of a scarcely perceptible breeze to upwards of 200 miles per hour.

VELOCITY AND POWER OF WINDS.

Velocity of Wind in Miles, per hour.	Common Names of Winds.
1	Hardly Perceptible Breeze.
4 to 5	Gentle Wind.
10 to 15	Pleasant Brisk Gale.
20 to 25	Very Brisk.
30 to 35	High Wind.
40	Very High.
50	Storm.
60	Great Storm.
80	Hurricane.
100	Violent Hurricane.
80 to 200	Tornado.

254. Cyclones are storms of considerable extent, in which the velocity of the wind is much greater than usual, and the air moves in eddies or whirls, somewhat similar to whirlwinds, but of vastly greater power and diameter.

In all such storms the wind revolves around a calm centre; over the calm centre the barometer is low, but on the sides, and especially on that side toward which the storm is moving, it is high.

Besides the rotary motion of the wind, there is also a progressive motion, which causes the storm to advance bodily, moving rapidly in a parabolic path. The general term *Cyclone* has been applied to these storms on account of their rotary motion. They have also various local names.

Cyclones originate in the tropical regions, but frequently extend far into the temperate zones.

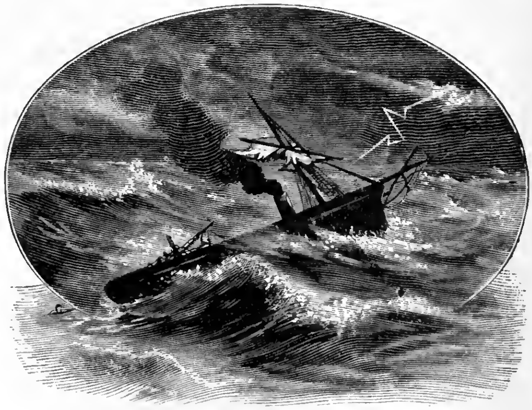


Fig. 87. A Storm at Sea.

255. Regions of Cyclones.—The following are the most noted regions:

The West Indies, where they are generally called *hurricanes.*

The China Seas, where they are known as *typhoons.*

The Indian Ocean.

In each of these regions the storms occur about the time of the change of the regular winds, and have their origin in marked differences of temperature; thus in the Indian Ocean and the China Seas, they generally occur *at the change of the monsoon, after the great heat of summer.* They are attended with the condensation of moisture and intense electrical disturbance.

256. Cause of Cyclones.—Cyclones originate in an area of low barometer caused by the ascending current of air that follows the overheating of any region. As the air rushes in from all sides it is deflected by the earth's rotation, and assumes a rotary or whirling motion around the heated area. The centrifugal force generated by this rotation causes the barometric pressure of the area to become lower and the area to grow larger. Meanwhile the inflowing air, ascending, is chilled by the cold of elevation and by expansion sufficiently to condense its vapor rapidly. The heat energy, previously latent in the vapor, is now disengaged, and causes the air to mount higher and condense still more of its vapor. It is to the energy thus rapidly liberated by the condensation of the vapor that the violence of the cyclone is due. Cyclones, therefore, acquire extraordinary violence only when an abundance of vapor is present in the air.

As the inblowing winds come near the heated area, they must blow with increased violence in order to permit the same quantity of air to pass over the constantly narrowing path.

Besides the rotary motion of the wind, the storm moves or progresses over a parabolic path, which in the tropics is generally toward the west, and in the temperate zones toward the east. This progressive motion of the storm is like the similar

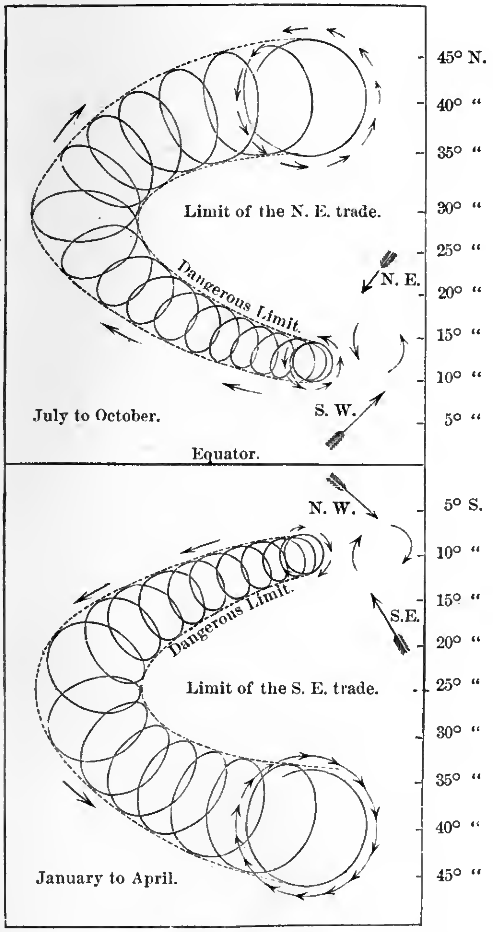


Fig. 88. Chart showing Path and Direction of Cyclone.

motion often noticed in a rapidly spinning top. It is due to the combined influences of the inrush of air, the earth's rotation, and centrifugal force.

257. Peculiarities of Cyclones.—Cyclones rage most furiously in the neighborhood of islands and along the coasts of continents. They are most powerful near their origin. As they advance the spiral increases in size and the fury of the wind gradually diminishes, because the amount of moisture in the air is less. The rotary motion varies from 30 to 100 miles an hour. The progressive motion of the calm centre is more moderate—from 20 to 50 miles an hour. This progressive motion is least in the tropics and greatest in the temperate regions.

The wind invariably rotates in the same direction in each hemisphere; in the northern, it rotates from *right to left,* or in the direction opposite to that of the hands of a watch; in the southern, from *left to right,* or in the same direction as the hands of a watch. The cause of the regu-

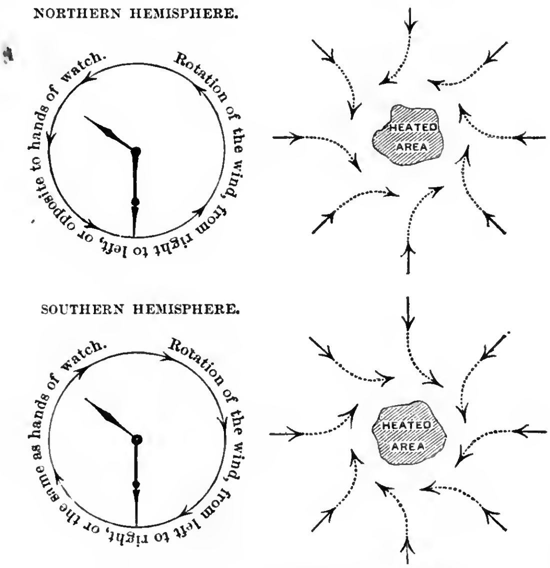


Fig. 89. Cause of the Rotation of the Wind.

larity of rotation is seen, from an inspection of Fig. 89, to be due to the rotation of the earth. The wind, blowing in from all sides toward the heated area, is so deflected by the rotary motion of the earth as to move in vast circles, from right to left in the northern hemisphere, and from left to right in the southern.

The force of the wind in these storms is tremendous. So furiously does the wind lash the water that its temperature is often sensibly raised by the friction.

The intelligent navigator always endeavors to avoid the centre of the storm, since it is the most dangerous part. This he can do by remembering the direction of the rotation of the wind in the hemisphere he may be in; for if, in the northern hemisphere, he stands so that the wind blows directly in his face, the calm centre *is on his right,* while in the southern hemisphere *it is on his left;* and instead of running with the storm, hoping to outsail it, he will boldly steer toward its circumference.

258. Tornadoes and Whirlwinds are the same as cyclones, except that they are more limited in area. Their violence, however, often exceeds that of cyclones. Tornadoes appear to be due to rotary motion of the air occurring above the earth's surface, which results in a rapid sucking up of the warmer surface air.

259. Water-spouts.—When tornadoes or whirlwinds occur on the water they cause a *water-spout.* A rapid condensation of vapor takes place, both from the different temperature of the winds and from the rarefaction produced at the centre of the revolving mass of air.

Portions of the clouds are sometimes drawn down from above and whirled around in the form of an immense funnel-shaped mass; finally the whirl reaches the water, and a column of spray is thrown up, which unites with the mass above and moves over the surface of the water as an immense pillar. Though of formidable appearance, water-spouts have never been known seriously to damage large vessels.

Similar phenomena are noticed on the land when tornadoes occur. Here, however, only the cloud cone is observed.

260. The North-Easters and other Storms of the United States.—The following important facts have been discovered in regard to the extended storms which occur in the United States:

(1.) All our great storms are attended by an immense whirling of the wind, and are, in fact, species of cyclones.

(2.) The great north-east storms of our eastern sea-board originate in the west, in an area of low barometer, somewhere between Texas and Minnesota. In the front and rear of this area the barometer is high.

(3.) The calm centre of the storm, or the area of low barometer, moves toward the north-east. The shape of the calm centre is longer from north to south than from east to west.

(4.) The storms begin by the winds blowing toward the area of low barometer.

(5.) During the prevalence of the storm the winds are north-east, east, or south-east; toward the end, north-west, west, and south-west.

261. Sailing Routes.—A knowledge of the directions of the winds and ocean currents has materially diminished the time required by sailing vessels to go from one port to another. Opposing winds and currents often render it advisable for the vessel to begin its journey in a direction considerably out of the direct line of the desired port.

Europe—America.—The Gulf Stream and prevailing westerly winds render the passage across the ocean from east to west considerably longer than from west to east. The general route, in either direction, varies with the season of the year.

New York—San Francisco.—After leaving New York the course is considerably to the east, in order to clear the South American coast in the region of the trades. After doubling Cape Horn the course is westward. The zone of the north-east trades is entered about 118° W. long.

America—India—Australia.—In sailing from America to India or Australia the vessel takes the same route as between Eastern America and San Francisco. About opposite Rio Janeiro, however, the routes diverge. On entering the Indian Ocean the direction is dependent on that of the prevailing monsoon.

Europe—India—Australia.—The vessels either pass through the Mediterranean Sea and the Suez Canal, or around the Cape of Good Hope. The broad expanse of ocean in the southern hemisphere, in the zone of the variables, renders the westerly winds very steady. Vessels sailing from Atlantic ports of America or Europe generally find it preferable to go by the eastward route, around the Cape of Good Hope, and return by the westward route, around Cape Horn, thus circumnavigating the globe.

California—Japan.—The southerly route, from east to west, is aided by the north-east trades and the north equatorial current of the Pacific; the northerly route, from west to east, is necessary in order to avoid the trade winds.

The general sailing routes between some of the most important ports are traced on the map of the winds.

SYLLABUS.

Atmospheric air is composed mainly of a mixture of nitrogen and oxygen, in the proportion, by weight, of about 77 parts of nitrogen to 23 of oxygen in every hundred parts. The atmosphere also contains small quantities of carbonic acid and the vapor of water.

The oxygen of the air is necessary to combustion and respiration; the carbonic acid and the vapor of water, to plant-life.

At the level of the sea the atmosphere presses on every square inch of the earth's surface with a force of about 15 pounds.

The upper limit of the atmosphere has been variously estimated at from 50 to 200 miles above the level of the sea.

A barometer is used for measuring the pressure of the atmosphere; a thermometer, for measuring its temperature.

The vertical rays of the sun are warmer than the oblique rays—1. Because they are spread over a smaller area of the earth. 2. Because they pass through a thinner stratum of air, and consequently lose less of their heat by absorption. 3. Because they strike the earth more directly, and therefore produce more heat.

Continual summer is found in the tropics; summer and winter of nearly equal length in the temperate zones; short, hot summers, followed by intensely cold winters, in the polar zones.

The atmosphere is heated—1. Either by direct absorption of the rays while passing through it; or 2. By contact with, or by radiation and reflection from, the heated earth.

Isothermal lines connect places whose mean temperature is the same.

The mathematical zones are bounded by the parallels of latitude; the physical zones, by the isotherms.

The mathematical and physical zones do not coincide—1. Because of the unequal distribution of the land and water areas. 2. The irregularities in the surface of the land. 3. The distribution of the winds and moisture. 4. The ocean currents. 5. The difference in the rainfall.

The temperature of the air decreases with the altitude —1. Because the air receives most of its heat from the earth's surface, so that it must grow continually colder the farther we go above the surface. 2. The decreased density and humidity of the air prevent it from absorbing either the direct rays of the sun or those reflected or radiated from the earth.

Places situated near the sea have a more equable, uniform climate than those in the same latitude in the interior of the continent.

Whenever any part of the earth's surface is heated more than the neighboring parts, ascending currents occur over the heated area, lateral surface currents blow in toward the heated area, and upper currents blow from the heated area.

The general system of the atmospheric circulation consists mainly of the following currents: 1. The polar currents, blowing from the poles toward the equator. 2. The equatorial currents, blowing from the equator toward the poles.

The direction of these currents is modified by the rotation of the earth. Thus modified, the equatorial currents are south-west in the northern hemisphere, and north-west in the southern. The polar currents are north-east in the northern hemisphere, and south-east in the southern.

When a wind at the surface blows in any direction, there is generally an upper current blowing in the opposite direction.

The equatorial currents do not continue as upper currents to the poles—1. Because they become cooled and fall. 2. From the contracted space of the higher latitudes when compared with that of the equator.

We distinguish the following wind zones: the zone of calms; the zones of the trades; the zones of the calms of Cancer and Capricorn; the zones of the variables; and the zones of the polar winds.

Land and sea breezes are caused by the unequal heating of the land and water during day and night; monsoons, by their unequal heating during summer and winter.

Monsoons occur on the coasts of tropical countries within the limits of the trade zones. They are most frequent in the Indian Ocean, in the Gulf of Guinea, and in the Mexican Gulf and neighborhood.

The Etesian Winds blow over the Mediterranean toward the Desert of Sahara.

The Hot Winds caused by the deserts of Sahara and Arabia are the Harmattan, over Guinea; the Solano, over Spain; the Sirocco, over Italy; the Simoom, over Arabia, Nubia, and Persia; and the Khamsin, over Egypt.

In most mountainous regions winds blow up the valleys toward the mountains during the day, and down the valleys from the mountains during the night.

Cyclones are caused by the wind blowing in from all sides toward an area of low barometer caused by the overheating of the area. The centrifugal force thus generated increases both the size of the area and the difference of pressure as compared with regions surrounding it. The fury of the storm is increased by the heat energy liberated by the condensation of the vapor in the uprushing air.

Storms occur whenever the ordinary equilibrium of the atmosphere is violently disturbed by wind, rain, snow, hail, or thunder and lightning.

Nearly all powerful storms are attended with a rotation of the wind. Such storms are known under the general names of Cyclones, Hurricanes, Typhoons, and Tornadoes.

The north-easters and other great storms of the United States are species of cyclones.

REVIEW QUESTIONS.

Of what use is the atmosphere in the economy of the earth?

Define meteorology.

Describe the construction of a barometer.

What proof have we that the greater part of the atmosphere, by weight, lies within a few miles of the earth's surface?

Define hypsometry.

Describe the construction of a thermometer.

Why are the vertical rays of the sun warmer than the oblique rays?

What is the characteristic climate of the tropics? Of the temperate regions? Of the polar regions?

In what different ways does the atmosphere receive its heat from the sun?

State the boundaries of the mathematical torrid zone. Of the physical torrid zone. Of the mathematical and physical temperate zones. Of the mathematical and physical frigid zones.

12

In what parts of the eastern hemisphere is the greatest mean annual temperature found? In what parts of the western hemisphere?

What influence is produced on the climate of high latitudes by a preponderance of moderately elevated land masses? On the climate of the tropics?

Why should the temperature of the atmosphere decrease with the altitude?

Name all the causes which prevent the mathematical climatic zones from coinciding with the physical climatic zones.

What is the origin of winds?

Name the currents of which the atmospheric circulation principally consists.

Explain the action of the rotation of the earth on the direction of the equatorial and polar currents.

Name the causes which produce the shifting of the equatorial and polar currents.

Name the principal wind zones of the earth.

Explain, in full, the origin of land and sea breezes. In what respect do monsoons resemble land and sea breezes?

Name the principal monsoon regions of the earth.

Describe the origin of desert winds?

Name the winds which are caused by the desert of Sahara. By the deserts of Arabia and Nubia.

What are storms?

What are cyclones? Where do they originate? In what direction does the wind rotate in the northern hemisphere? In the southern hemisphere? In what direction does the storm progress in each hemisphere? Explain the cause of the rotation of the wind.

What are hurricanes? Typhoons?

Explain the formation of a water-spout.

Is the water in the upper part of a water-spout salt or fresh?

Name the important facts which have been discovered respecting the north-easters and other severe storms of the United States.

MAP QUESTIONS.

Trace on the map of isothermal lines the areas of greatest heat in the eastern hemisphere. In the western hemisphere.

Show from the map of the isothermal lines wherein the physical torrid zone differs in position from the mathematical torrid zone.

In which hemisphere do the isothermal lines deviate more from the parallels of latitude, in the northern or the southern?

Trace on the map of the isothermal lines the limit of the Arctic drift ice. Of the Antarctic drift ice.

What are the mean summer and winter temperatures of Sitka? Of Quebec?

What causes exist to render the climate of Sitka so much warmer than that of Quebec, notwithstanding the difference of their latitudes?

What are the mean summer and winter temperatures of Mexico, Madras, Singapore, Berlin, London, Philadelphia, Algiers, Melbourne, and Rio Janeiro?

What instances can you find on the map of the increase in the mean annual temperature of places through the influence of ocean currents? Of winds? Of rainfall?

Name similar instances of places whose mean annual temperature is lowered by such causes.

Trace on the map of the winds the boundaries of the various wind zones. State the direction of the wind in each of these zones.

Point out the limits of the monsoon regions of the world.

What hot winds blow over Arabia? Over Egypt? Over Greece and Italy? Over Guinea?

What cold wind blows over Texas?

Describe the path of the West India hurricanes. How far to the north do these storms extend?

Describe the path of the Mauritius hurricanes. Where do these storms originate? How far to the south do they extend?

Describe the region of the typhoons.

Describe the route a vessel would take in sailing from America to Europe. From New York to San Francisco. From America to Australia.

SECTION II.

MOISTURE OF THE ATMOSPHERE.

CHAPTER I.

Precipitation of Moisture.

262. Evaporation.—From every water surface, and even from masses of ice and snow, there is constantly arising, at all temperatures, an *invisible vapor* of water. Water vapor is about three-fifths as heavy as air. It diffuses readily through the air, and is borne by the winds to all parts of the earth. This giving off of vapor from the surface of water is called *evaporation*. It is evaporation which dries the wet earth, when the moisture is unable either to pass off the earth's surface by drainage, or to soak through the porous strata.

About one-half, by weight, of the vapor of the atmosphere is within a little over a mile above the mean sea level.

263. The Rapidity of Evaporation is influenced by the following circumstances:

(1.) *The temperature of the atmosphere.* The capacity of the air for absorbing moisture increases with an increase of temperature. Warm air can retain more vapor than cold air.

(2.) *The extent of surface exposed.* Evaporation takes place only from the surface; therefore, the greater the surface, the greater the evaporation.

(3.) *The quantity of vapor already in the air.* Dry air absorbs moisture more rapidly than moist air. All evaporation ceases when the air is completely saturated.

(4.) *The renewal of the air.* During very calm weather, the air in contact with a water surface becomes saturated, and so prevents further evaporation. Gentle breezes, by renewing the air, increase the rapidity of evaporation.

(5.) *Pressure on the surface.* A diminished atmospheric pressure increases the rapidity of evaporation.

264. The Dew Point.—*When the air contains as much vapor as it is capable of holding, it is said to be at its dew point.*

The quantity of moisture necessary to saturate a given quantity of air and bring it to the dew point, varies with the temperature. Cold air requires less moisture to saturate it than air which is warmer, and, therefore, *may feel damper* than warm air, which may contain more vapor. We thus distinguish between the *actual humidity*, or the amount actually present in a given volume of air, and the *relative humidity*, or the relation between the amount present and that required to saturate the air at the given temperature.

The humidity of the air is determined by means of an instrument called a *hygrometer*.

Weight in grains of aqueous vapor in ONE *cubic foot of* SATURATED AIR *at different temperatures.* (*Silliman.*)

Temperature, Fahr.	Weight in Grains.	Approximate Values.
0°	0.545	0.6
10°	0.841	0.9
20°	1.298	1.3
30°	1.969	2.0
40°	2.862	2.9
50°	4.089	4.1
60°	5.756	5.8
70°	7.992	8.0
80°	10.949	11.0
90°	14.810	15.0
100°	19.790	20.0

No matter how much aqueous vapor a given quantity of air contains, if its temperature be lowered, *it will grow relatively moister until, if the fall of temperature be sufficient, its dew point is reached;* and as soon as the temperature falls below the dew point, a deposition of moisture will begin, either in the liquid or solid state.

265. Precipitations.—The invisible vapor may be precipitated from the atmosphere and become visible, either as *dew, mist, fog, cloud, rain, sleet, hail, or snow.* These are called *precipitations.*

Law of Precipitations.

In order that any precipitation may occur, the air must be cooled below the temperature of its dew point.

266. Distribution of Precipitations.—The quantity of moisture in the air depends on its temperature, and its vicinity to the sea.

The amount of precipitation regularly decreases as we pass from the equator to the poles, and from the coasts of the continents toward the interior.

267. Dew.—If, during a warm day, a dry glass be filled with cold water, the outside of the glass will soon become covered with small drops of water, derived entirely from the air. The air which comes in contact with the cool sides of the glass has *its temperature lowered below the dew point*, and deposits as vapor the moisture it no longer can retain.

The dew which is deposited during certain seasons of the year on plants and other objects on the earth, has a similar origin. Objects on the earth cool more rapidly than the surrounding air, which deposits its moisture on them whenever they lower its temperature below the dew point. When the objects are colder than 32° Fahr., the dew is deposited as *hoar-frost.*

Dew falls more heavily on some objects than on others; this is because some objects *radiate* or give off their heat more rapidly than others, and thus becoming cooler, they condense more of the moisture of the air.

More dew falls during a clear night than during a cloudy one, because objects cool more rapidly when the sky is clear than when it is cloudy.

Thick clothing keeps the body warm, not because *the clothes give any heat to the body,* but because they are *non-conductors,* and prevent the escape of heat from the body. In like manner the clouds, acting as blankets to the earth, prevent its losing heat rapidly.

More dew falls during a still night than during a windy one.

The air must remain long enough in contact with cold objects to enable them to lower its temperature and collect its moisture. Powerful winds prevent this, while gentle breezes favor the deposition, by bringing fresh masses of air into contact with the cold objects.

In the tropics, during seasons when the sky is clear, the dew is so copious that it resembles a gentle rain.

In the deposition of dew, the moisture is derived from a comparatively thin stratum of air in the immediate neighborhood of the cool object. All other kinds of precipitations are produced by the cooling of *a large mass of air.*

268. Fogs and Clouds.—Whenever the temperature of a large mass of air is reduced below its dew point, its moisture begins to collect in minute drops, which diminish the transparency of the air, and form *fogs* or *mists,* when near the surface, and *clouds,* when in the upper regions of the atmosphere. *Fogs and clouds are the same in their origin and composition, and differ only in their elevation.*

The minute drops of water that form clouds and fogs, though formed of a substance about eight hundred times heavier than air, are prevented from settling rapidly by the resistance of the air. This is rendered possible by the minute size of the drops, which are much smaller than the relatively heavier dust-particles, which are wafted about by the winds. Whenever the drops exceed a certain size, they fall as rain or snow.

It was once believed that the moisture in fogs and clouds existed in the form of hollow bubbles or vesicles, filled with air, and that the clouds or fogs ascended, whenever the contained air expanded the bubbles and rendered them specifically lighter. This idea is now generally abandoned.

Clouds or fogs result whenever a mass of air is cooled below the temperature of its dew point, as, for example, when two bodies of air of different temperatures are mingled, especially if, as is generally the case, the warmer of the two is the moister. On the contrary, clouds or fogs disappear on the approach of a dry, warm wind. Clouds are higher in the tropics than in the polar regions, and generally are higher during the day than during the night.

Off the banks of Newfoundland, the warm, moist air of the Gulf Stream is cooled by the cold, moist air of the Labrador ocean current. Hence result the dense fogs so frequent over this part of the ocean.

269. Classification of Clouds.—Clouds assume such a variety of shapes, that it is difficult to classify them. Meteorologists, however, have recognized the existence of *four primary forms:* the *cirrus,* the *cumulus,* the *stratus,* and the *nimbus.*

Fig. 90. Primary Forms of Clouds.
Cirrus. Cumulus.

The Cirrus Cloud consists of fleecy, feathery masses of condensed vapor, deposited in the higher regions of the atmosphere. The name cirrus is derived from the resemblance the cloud bears to a lock of hair. These clouds are called by sailors *cats' tails* or *mares' tails.* From their elevation, the moisture is, probably, generally in the condition of ice-particles. Halos, or circular bands of light around the sun, are caused by light passing through cirrus clouds.

The Cumulus, or Heap Cloud, is a denser cloud than the cirrus, and is formed in the lower regions of the air, where the quantity of vapor is greater. Cumulus clouds generally consist of rounded masses, in the shape of irregular heaps, with moderately flat bases. They are caused by ascending currents of air, which have their moisture condensed by the cold produced by expansion and elevation. Cumulus clouds occur during the hottest part of the day. Their height seldom exceeds two miles.

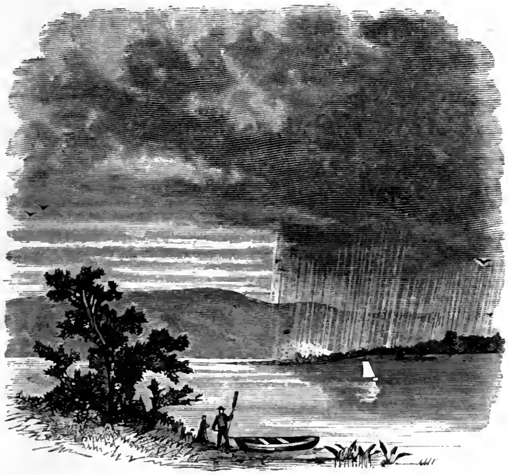


Fig. 91. Primary Forms of Clouds.
⌄ Nimbus. ⌄ ⌄ Stratus.

The Nimbus, or Storm Cloud, is any cloud from which rain falls. Any of the various forms of clouds may collect and form a nimbus cloud. The nimbus is not considered as a distinct form of cloud by some meteorologists.

The Stratus, or Layer Clouds, form in long, horizontal sheets or bands. These clouds are most common in the early morning and evening, when the ascending currents are weak. They are caused by the gradual settling of cumulus and other clouds. The stratus is the lowest form of cloud; it sometimes falls to the surface of the earth, and becomes a fog.

The cirrus, stratus, and cumulus clouds assume a variety of shapes, producing various secondary forms.

270. Secondary Forms of Clouds.—The *cirro-stratus*, the *cirro-cumulus*, and the *cumulo-stratus* are the most prominent secondary forms of clouds. The first two are modifications of the cirrus cloud; the latter, of the cumulus.

Fig. 92. Secondary Forms of Clouds.
⌄ Cirro-Cumulus. ⌄ ⌄ Cirro-Stratus. ⌄ ⌄ ⌄ Cumulo-Stratus.

The Cirro-Cumulus is a cirrus cloud, arranged in little rounded masses, shaped something like cumuli. They are sometimes called "wool sacks," and indicate dry weather.

The Cirro-Stratus is a cirrus cloud which has settled in bands or layers. The bands are not continuous, but are arranged in blotches or bars, and often give to the sky the speckled appearance of a mackerel's back, producing the so-called *mackerel sky.*

The appearance of a mackerel sky indicates—1. That the moisture of the *upper strata* of air *is condensing;* 2. That it is growing dense enough to arrange itself in layers. Therefore, a mackerel sky generally indicates approaching rain.

The Cumulo-Stratus is the form produced by the heaping together of a mountain-like mass of cumulus clouds; the base partakes of the nature of the stratus cloud, but the top clearly resembles cumuli. These clouds differ but little from the nimbus, or storm cloud.

271. Rain.—When, during the formation of a cloud, the condensation of moisture continues, the drops of which the cloud is composed increase in size, and, uniting, fall to the earth as *rain.* Rain which freezes while falling forms *sleet.* As the drops fall through the cloud they grow larger by the addition of other drops which unite with them. Raindrops, therefore, are larger when the clouds are thicker. They are, in general, larger in the tropics than in the polar regions, and during the day than at night.

To produce rain, it is necessary that the temperature of a large mass of air be reduced considerably below its *dew point*. There are several ways in which this cooling may be effected:

(1.) *By a change of latitude.* A warm, moisture-laden wind may blow into a cold region. The equatorial currents of air deposit their moisture in the temperate and polar zones on account of the chilling experienced as they recede from the equator.

(2.) *By a change of altitude.* By an ascending current of air, which carries the moisture of the lower strata into the upper regions, where the cold there existing, together with that produced by the rapid expansion of both air and vapor under the diminished pressure, condenses the moisture of the air. It is mainly in this manner that the rains of the tropical regions are caused.

The rain in mountainous districts has a similar cause. A moist wind, reaching a mountain-range, is forced by the wind back of it to ascend the slopes. Contact with the cold, upper slopes causes condensation of the vapor as rain.

(3.) *The mingling of masses of cold and warm air.* By this means heavy clouds and a moderate rainfall may be produced; but the precipitation can never be considerable, because the cooler air will be warmed by the mixing, and, therefore, will have its capacity for moisture increased instead of diminished.

272. Distribution of the Rainfall.—The distribution of rain may be considered both as regards its *periodicity* and its *quantity*. The distribution of the rain is dependent upon the direction of the winds. Each wind zone has a characteristic rainfall.

The following simple principles determine the rainfall in any particular wind zone:

(1.) *The equatorial currents are rain-bearing,* because they are moist, and while on their way to the poles, their temperature and consequent capacity for moisture, is constantly decreasing.

(2.) *The polar currents are dry,* because they are constantly increasing in temperature as they approach the equator; hence they take in, rather than give out, moisture.

When they have reached the zones of the trade winds, the polar currents may bring abundant rains, provided they have previously crossed an ocean. They then discharge the moisture with which they are saturated, either by an ascending current, or by blowing against the elevations of the continent.

273. Periodical Rain Zones.

The Zone of Calms.—In the zone of calms it rains nearly every day. In the early morning the sky is cloudless; but near the middle of the day, as the heat increases, the ascending currents, rising higher, begin to condense their moisture; cumuli clouds form, and, increasing rapidly, soon cover the sky, when torrents of rain descend, accompanied by thunder and lightning. After a few hours the rain ceases, and the sky again becomes clear. In this zone it seldom rains at night.

274. The Zone of the Trades.—Since the trades are generally dry winds, it is only when their temperature is considerably decreased that they can cause rain. In the zone of the trades, except in mountainous districts and on the windward coasts of a continent, the rainfall occurs during the greatest heat of the season, when the sun is directly overhead and the ascending currents are powerful. Hence, *it rains* during a few months *in summer*, when immense quantities of water fall; the remainder of *the year is dry.* Copious dews, however, occur at night.

The precipitation is not continuous throughout the entire summer. Since the rain only falls when the sun is nearly overhead, a brief interval of dry weather occurs in regions near the equator, thus dividing the season into two parts: one, during the passage of the sun over the zenith; the other, on his return to the zenith from the adjacent tropic. Near the limits of the zone, however, the two seasons are merged into one.

Over the ocean, during most of the year, there is no rain in the zone of the trades, although the actual humidity of the air is quite high.

Between latitude 24° and 30°, in both the Northern and Southern Hemispheres, there are regions of comparatively scanty rains. Here the summers are not hot enough to cause rain by the ascending currents, but are sufficiently hot to prevent the equatorial current from bringing much rain. Here also the return branch of the equatorial current becomes drier on its return to the equator.

275. The Monsoon Region of the Indian Ocean.—During the prevalence of the winter monsoon, the north-east winds bathe the eastern shores of Hindostan in copious rains, while the western shores, shielded by the ranges of the Ghauts, are dry. During the summer monsoon, the south-west winds bathe the western shores and the southern slopes of the Himalayas in heavy rains, while the eastern shores are dry. This monsoon also brings rains to the western coasts of the peninsula of Indo-China.

276. Non-Periodical Rain Zones.

The Zones of the Variable Winds.—In these zones rain may occur at any season of the year, and at any hour of the day or night. Here it is the equatorial currents which bring the rain. These regions are sometimes called the zones of *perennial rains, or of constant precipitation.* In the greater part of these zones, the equatorial currents are more frequent in summer than in winter. The rainfall is, therefore, greatest during summer.

Rainfall in the Zone of the Polar Winds.—In these zones the winters are dry, because the dry, cold polar currents then prevail; but during the summer the equatorial currents sometimes prevail, and bring with them dense clouds and fogs, accompanied by drizzling rains. The snows occur mainly in spring and autumn.

277. Quantity of Rain.—The quantity of rain which falls in a given time on any area is determined by means of an instrument called the *rain-gauge* or *pluviometer.*

The rain-gauge is generally constructed in the form of a cylindrical vessel with a horizontal base, surmounted by a funnel-shaped top. A vertical glass tube communicates with the bottom of the vessel from the outside, and allows the water to mount in it to the same height as that in the inside. The rain-gauge is placed in an exposed position, where it is free from eddies or whirls. If, during any given time, the water in the instrument is one inch deep, then during that time the rainfall over the area equals one inch. In speaking of the rainfall of a country, the moisture which may fall as snow is always included.

An inch of rain over a surface a square yard in area equals in weight 46⅔ pounds: on the surface of an acre, it is nearly equal in weight to 100 tons.

The annual rainfall is distributed, as regards quantity, as follows:

Irrespective of the elevations of the surface, *more rain falls in the tropics than in the temperate regions, and more in the temperate than in the polar regions.* The quantity thus decreases with moderate regularity from the equator toward the poles. This is caused by a similar decrease in the quantities of heat and evaporation.

While the amount of rain that falls decreases from the equator to the poles, the number of cloudy or rainy days increases, being greater at the poles than at the equator.

More rain falls on the coasts of a continent than in the interior, since near the ocean the winds are moister. That coast of a continent which first receives the prevailing wind has the greatest rainfall.

More rain falls in the Northern Hemisphere than in the Southern. This is due to the greater extent of the land-area of the Northern Hemisphere.

Mountains receive a heavier rainfall than the plains below, because the moist winds, in order to cross the mountains, are forced to ascend their slopes and thus pass into a colder region of the atmosphere. Therefore, the sources of rivers are generally found in mountainous districts. Mountains are among the most important causes of rain.

When the mountains are high, the winds may reach the opposite slopes dry and vaporless. The tropical Andes of South America afford an excellent example of this.

Plateaus, though higher than plains, receive, as a rule, less rain, because they are generally surrounded by mountain chains, which rob the winds of their moisture. Moreover, the air over a plateau is warmer than at a corresponding height in the atmosphere, and therefore dissolves, rather than condenses, the moisture.

The rainfall of the New World, both in the tropical and temperate regions, *is greater than that of the Old;* thus, in the tropics of the New World, 115 inches of rain fall yearly, while the same portions of the Old World receive but 77 inches. In the temperate zones in America the annual rainfall is 39 inches, while in Europe it is but 34 inches.

The mean annual rainfall at Philadelphia, according to Prof. Kirkpatrick, is 46.93 inches. The figures are based on observations during 16 consecutive years.

The preceding principles find ample illustration in the following tables:

TABLE OF ANNUAL RAINFALL (H. K. Johnston).

Rainfall in the Tropics.

OLD WORLD.	Inches.	NEW WORLD.	Inches.
Ceylon	91.7	San Luis de Maranhão, Brazil	280.00
Hindostan, mean of the Peninsula	117.5	Cayenne, Guiana	116.27
Sierra Leone, Guinea	189.6	Paramaribo, Guiana	229.20
Macao, China	68.3	Grenada, Lesser Antilles	103.41
Canton	69.2	Havana, Cuba	90.66

Rainfall in the Temperate Zone.

EUROPE.

	Inches.		Inches.
Madeira	29.82	Southern France	23.54
Sicily	23.55	Southern Germany	26.64
W. side of Apennines	35.17	Netherlands	26.70
E. " "	26.70	British Islands, Plain	27.00
S. " Alps	57.57	" " Mts	50.00
N. " "	35.27	W. Coast Scandinavia	82.12

Mean Rainfall in Europe in the Temperate Zone..........34 *inches.*

AMERICA.

	Inches.
Key West, Florida	35.26
Charleston, S. C.	47.60
Washington, D. C.	36.30
Marietta, Ohio	34.16
West Chester, Penna	46.89
Cambridge, Mass.	38.42
Burlington, Vt.	39.44
Eastport, Maine	36.28
New York	36.28

Mean Rainfall in the United States in the Temperate Zone..........39 *inches.*

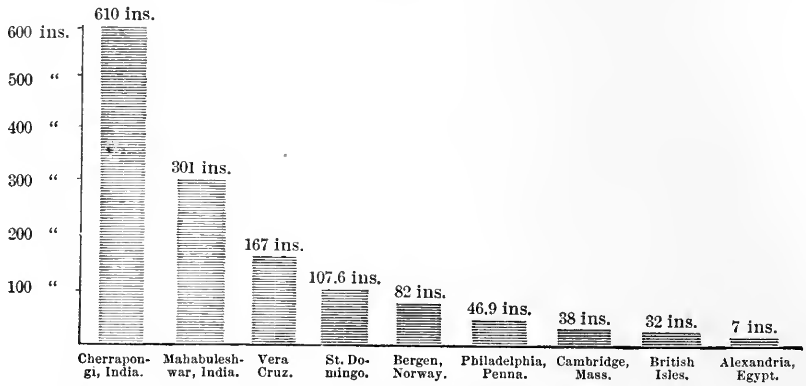


Fig. 93. Comparative Rainfall. (The figures represent the annual rainfall in inches.)

278. Rainless Districts.—In some parts of the world, rain is either entirely absent, or falls only in limited quantities, at long intervals. The most extensive rainless districts are found in the eastern continent.

Desert Belt of the Eastern Continent.—From the western shores of Northern Africa eastward to the Great Kinghan Mountains in Asia, extends an almost uninterrupted belt of desert lands. It includes the great desert of the *Sahara, the Arabian and Persian Deserts, and the Desert of Mongolia.* The aridity is most absolute in the west, where, in the Sahara and in the desert of Arabia, rain seldom, if ever, falls. Toward the east, in Persia and Mongolia, scanty rains occur, but the country has the appearance of a desert.

The cause of this immense desert tract is to be found in the dry trade winds, which blow over most of the region. Having previously crossed the vast continent of Asia as upper currents, they arrive at the deserts dry and vaporless. Even that portion of the region which receives the winds from the Mediterranean has no rainfall, because any clouds that may form, are soon dissipated by the hot air of the desert.

Persia and Mongolia owe their deserts to their high mountain borders, which rob the clouds of their moisture before they cross the interior plateaus. The high system of the Himalayas effectually prevents any of the moisture of the southwest currents from penetrating the plateau of Mongolia.

Arid tracts occur in the Kalahari desert, in Africa, and near the tropic of Capricorn, in Australia.

Desert Belt of the Western Continent.—The desert lands of the Western Continent are more contracted in area. *In North America,* the largest desert is in the Great Interior Plateau. Here the mountain borders, especially the Sierra Nevada on the west, deprive the interior of rain. The aridity is not absolute, since scanty rains occur over parts of the region. Portions of the peninsula of California and of the Mexican Plateau also resemble deserts.

In South America, on the western slopes of the Andes, between the parallels of 27° and 23° S., is found the desert of Atacama. Here rain never falls, although the ground is occasionally refreshed by mists and dews. The cause of the absence of rain is to be traced to the high Andes, which condense all the moisture of the trades on their eastern slopes, the winds thus arriving dry and vaporless at the western.

Cause of Deserts.—*Deserts are caused entirely by the absence of moisture.* Their soil, though generally finely pulverized, or sand-like, does not differ, save in the absence of vegetable mould, from that of other areas. Thus neither the nature of its temperature, nor its soil, is the cause of the desert of Sahara, since a vigorous vegetation always follows the appearance of water, on the successful boring of an artesian well. It is probably true that deserts, once formed, tend to perpetuate themselves, by the influence their naked surfaces exert on the rainfall.

CHAPTER II.

Hail, Snow, and Glaciers.

279. Hail falls when considerable differences of temperature exist between higher and lower strata of air, and the moisture is suddenly condensed in the presence of great cold. Generally, several layers or bands of dark, grayish clouds are seen. Hail falls most frequently in summer, near the close of an excessively warm day.

Structure of the Hailstone.—If a large hailstone be placed on a hot surface until one-half is melted, the structure can be readily examined. Concentric layers, similar to those of an onion, will be noticed, arranged around a central nucleus, sometimes of ice and sometimes of snow, though generally the latter. The stones are more or less oblately spheroidal in shape. Their general weight varies from a few grains to several ounces, but they have been known to weigh several pounds.

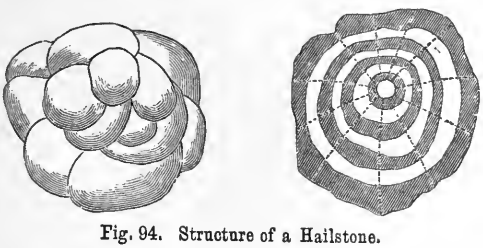


Fig. 94. Structure of a Hailstone.

Origin of Hail.—The cause of hail is not exactly understood, and several theories have been framed to account for it. One of these is the Rotary Theory.

The wind is supposed to rotate as in a cyclone, only the axis of the whirl is horizontal instead of vertical. Two horizontal layers of cloud exist—the upper layer of snow, the lower, of rain. The snowflakes, which form the nuclei of the hailstones, are caught in the whirl, and dipped in rapid succession into the two clouds, thus receiving alternate coatings of ice and snow, until at last they are hurled to the ground.

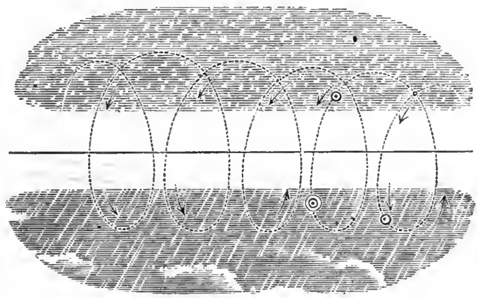


Fig. 95. Rotary Theory of Hail.

Thunder and lightning are the invariable attendants of hailstorms, and some authorities have attributed the formation of the stones to successive electrical attractions and repulsions of the snowflakes between a snow and a rain cloud. Others have imagined a number of alternate layers of snow and rain, and have attributed the hailstones to drops of rain falling through the successive clouds.

280. Snow.—When the moisture of the air is condensed at any temperature below 32° Fahr., the vapor crystallizes, and snowflakes are formed.

The snowflakes grow, as they fall, by condensing additional moisture from the air. They are larger in mild than in cold weather.

Snow-crystals assume quite a variety of forms, but are built up by various groupings of minute rhombohedrons of ice. The star-shape is the most common.

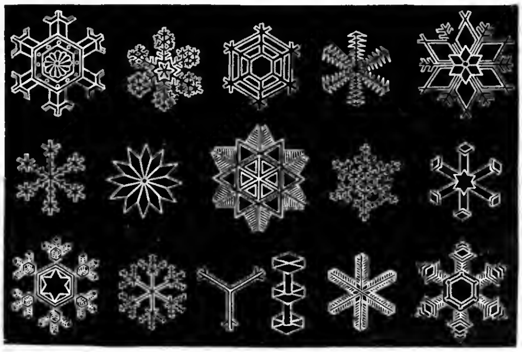


Fig. 96. Snow-Crystals.

If the temperature of the air near the surface is much warmer than 32° Fahr., any snow that is formed in the upper regions will melt before reaching the ground. Hence, in the temperate zones, as a rule, snow falls only in winter, while in the tropics it never falls, except near the summits of lofty mountains.

It is a mistake to suppose that the fall of snow is greater in regions near the poles than elsewhere; for in high latitudes there is comparatively little moisture in the air. The fall is heaviest in the cool temperate regions.

281. Snow Line.—The snow which falls on mountains is slowly pressed down the slopes by the weight of the snow above. The distance it will move down the mountain before melting depends on a number of circumstances. The lower limit of the line, above which the ground remains covered with snow throughout the year, is called the snow line.

The height of the snow line depends—

(1.) *On the amount of the snowfall.* The greater the fall, the farther down the mountain the snow will move before melting.

(2.) *On the temperature of the valley.* The warmer the valley the higher the snow line. The snow line is, therefore, highest in the tropical regions, and lowest near the poles.

(3.) *On the inclination of the mountain slope.* The steeper the slope, the more rapidly the snow will move down the mountain, and the farther it will go before melting, therefore, the lower the snow line.

According to Guyot, the snow line, subject to variations, is about three miles above the sea in the tropics; rather less than two miles in the temperate latitudes; and less than a mile near the northern extremities of the continents; while still farther north, on the polar islands, the snow line is but a few hundred feet above the sea. Over the polar oceans, the winter snows are but partially melted, and help to produce the huge *ice-floes* of these regions.

SNOW LINE.

Europe.—Norway, lat. 70° N	3,400 feet.
" " " 60° N	5,500 "
" Alps, lat. 46° N. (south side)	9,200 "
" " " " (north side)	8,800 "
Asia.—Altai Mountains, lat. 50° N	7,000 "
" Himalayas, lat. 31° N	17,000 "
Africa.—Kilimandjaro, lat. 3° S	16,000 "
North America. — Rocky Mountains, lat. 43° N	12,467 "
South America.—Andes, Ecuador, lat. 1° S.	15,800 "
" " " lat. 54° S	3,700 "

The snow line is generally lower in a moist atmosphere than in dry air, because of the greater fall of snow in the former case than in the latter. *As a rule, that slope of a range which is exposed to the prevalent wind has a lower snow line than the opposite slope.* The position the slope occupies in relation to the vertical rays of the sun, also exerts an influence on the height of the snow line.

282 Glaciers are immense masses of ice and snow, which move almost imperceptibly down the higher mountain valleys or slopes. Their upper parts are formed of soft snow; their lower portions of clear, hard ice. Their origin is as follows: The weight of the huge snow fields, which form above the snow line, presses the mass slowly down the slopes. The pressure, due to the weight of the layers, but especially the pressure which is produced when the mass is forced through a contraction in the valley, squeezes out the confined air, to which snow, in great part, owes its white color, and the lower part of the glacier thus becomes changed into a compact mass of pure ice. The alternate thawing and freezing to which the mass is subjected below the snow line, also contribute to the change from snow to ice.

The change is most thorough in the lower parts of the glacier, where the ice is marvellously clear. Its color, when seen in great depths, is of a deep azure blue; in the middle portions of the glacier the ice is coarse and white. The higher region of but partially changed snow is called *the névé region.* Here the snow occurs in coarse white grains. The process of formation is a continuous one. The névé region is supplied by fresh falls of snow, which replace those pressed down the slopes.

283. Drainage of Snow and Ice.—Glaciers closely resemble rivers, since they receive the drainage of their basins through the solid material which flows into them; their motion, however, is much slower. Like rivers, they have their tributaries, and their peculiarities of flow and velocity.

Several glaciers often unite and flow on as one mass; but their solid condition prevents the intermingling which occurs in rivers, and the separate streams can generally be distinctly traced throughout the remainder of their course. Like rivers, the top and middle portions move more rapidly than the sides or bottom, owing to the diminished friction.

284. Peculiarities of Glaciers.—The surface of the glacier is often comparatively smooth; but when irregularities occur, either in the direction of the valley, or in the slope of its bed, the glacier is broken into deep fissures, called *crevasses.* These are most numerous on the sides, from which they extend either obliquely up the stream, or directly across, in deep transverse fissures. The former are generally due to a bend in the valley, one side being compressed and the other extended; the latter, to steep and abrupt descents in the bed. *Crevasses are, therefore, rapids in the ice stream.*

Crevasses vary in breadth from mere crevices, that a knife-blade can scarcely penetrate, to yawning chasms over 100 feet in width. The depth of the wider crevasses is generally profound. Their vertical walls afford a convenient opportunity for studying many peculiarities of formation. Looking down the walls of the crevasses, the ice appears of a deep azure blue. The surface ice is a dirty white.

The crevasses gradually disappear below the cause of disturbance, the fractures rejoining by a process called *regelation*. Regelation is the property which fragments of moist ice have of becoming firmly cemented together, when their surfaces are brought into contact under pressure.

The water derived from the melting of the ice issues from a cavernous arch at the end of the glacier. The volume of the issuing stream, which is often considerable, is dependent on the temperature, being greater during the warm months of the year. Many rivers have their origin in these glacier streams; as, the Rhone and the Rhine, in Europe, and the Ganges, in Asia.

The distance the glacier extends below the snow line depends on the mass and velocity of the ice, and the rapidity with which it is melted. When the winter snows are light, and the following summer unusually warm, the end of the glacier retreats up the mountain. On the contrary, heavy snowfalls in winter, followed by a cool summer, permit the end of the glacier to advance far into the valley below.

285. Transporting Power of Glaciers.—All along the borders of the valleys, stones and dirt roll down the declivities, and, accumulating on the surface of the moving mass, are carried with it to a lower level. These accumulations of dirt and stones are called *moraines;* they are most sharply marked at the sides of the glaciers, where they are called *lateral moraines*. Where two glaciers flow into one common valley a moraine called the *medial moraine* marks the junction of their meeting edges. At the end of the glacier, a *terminal moraine* extends in a wide curve across the valley. Medial moraines are sometimes over a hundred feet in height. Terminal moraines sometimes attain the height of several hundred feet.

The masses of stone transported by glaciers are often of great size. Some have been found 100 feet long, 50 feet wide, and 40 feet high.

286. Erosion.—Such immense masses of ice must deepen considerably the valleys through which they move. When they have deserted their former valleys, evidences of their previous existence are to be found in the long lines of unstratified rocks and mud left by their moraines and boulders, and especially in the deep grooves, or scratches, cut in the bottom or sides of the valleys by rocks imbedded in the moving ice mass. These scratches are parallel, and show the direction of the motion.

The water which issues from the terminal cave is deeply charged with a fine sediment, the result of erosion. This sediment is exceedingly fertile, and, spread out by the rivers on the flood-grounds, becomes a source of agricultural wealth.

Fiords and Glacial Lakes.—Valleys cut by glaciers are characterized by parallel sides. Glacial valleys, when formed on mountains that slope down to the ocean, if the region is subjected to subsequent depression and the valleys partially submerged, are penetrated by the sea, and form arms of the sea extending far into the mountains. Such valleys are called fiords.

The following are the most important fiord regions:

(1.) On the coasts of Norway.

(2.) On the western coasts of the Dominion of Canada and Alaska.

(3.) On the coasts of Greenland, where the valleys are still covered with ice masses.

The numerous lakes of glacial regions owe their origin either to the erosion of softer rocks, or to the damming up of rivers by the terminal moraines left by a retreating glacier.

287. Geographical Distribution of Glaciers.—The best known glacial system in the world is found in Europe, in the region of the Central Alps. Here no less than 1100 glaciers are found, one hundred of which are of large size.

One of the best known of the European glaciers is that of the *Mer de Glace* (Sea of Ice). It descends from the slopes of the range of Mont Blanc, and is formed by the confluence of three large glaciers: *the Glacier du Géant, the Glacier de Léchaud, and the Glacier du Talèfre.*

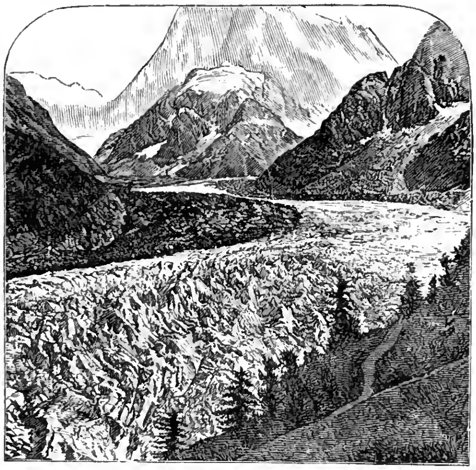


Fig. 97. The Mer de Glace.

Glaciers occur also in the Pyrenees Mountains; in the Caucasus range; and in the Scandinavian plateau, from which they descend into the Norwegian fiords to less than 1000 feet from the level of the sea. They also occur in the Patagonian Andes

In the Arctic zone glaciers are particularly numerous and extensive. Here they generally reach down into the sea. They are found in the islands of the Arctic Archipelago, in Greenland, Iceland, Jan Mayen, and Spitzbergen.

The Humboldt Glacier, in Greenland, is sixty-nine miles broad at its lower extremity in the sea. In all the Arctic glaciers, the névé region is more extended than in those of more southern latitudes. The terminal moraines are found at the bottom of the sea, near the foot of the glacier.

In the lofty mountain-ranges of the Himalayas and in the Karakorum, occur other less known, though extensive, regions of glaciers.

288. Icebergs.—When the glacier extends into the sea, the base is undermined by the warmer waters of the ocean, and great fragments are broken off by the waves, forming floating mountains of ice, called *icebergs*. Icebergs are particularly numerous in the North Atlantic, into which they descend from the extensive Arctic glacial region already described.

The limits of the Arctic and Antarctic drift ice are shown in the map of the isotherms.

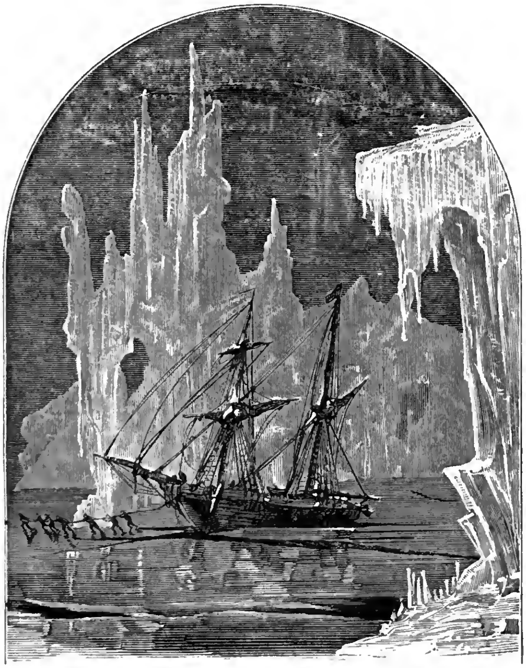


Fig. 98. Icebergs.

The *ice floes* of the polar seas have their origin in the snow which falls into the cold water, remaining partially dissolved and subsequently freezing, thus adding to the thickness of the ice formed.

289. The Glacial Epoch of the Earth.—Toward the close of the Mammalian Age, a change occurred in the climate of the earth, and extensive glaciers covered most of the northern continents, reaching, in many instances, far toward the south. In the United States, their southern limit appears to have been at about lat. 39° N., in Southern Pennsylvania, Ohio, Indiana, Illinois, and Iowa. In Europe, they extended as far south as the 50° N. lat. In South America, they probably extended as far toward the equator as 41° S. lat.

The evidences of the existence of ancient glaciers are found in the presence of accumulations of unstratified material, called the *drift;* in the presence of old moraines; in glacial scratches and grooves on rocky slopes; in eroded valleys; and in the presence of numerous large boulders, which are found at great distances from their places of origin.

CHAPTER III.

Electrical and Optical Phenomena.

290. Nature of Electricity.—Electricity is now generally believed to be due to a peculiar wave motion in the luminiferous ether, the medium which transmits the waves of light and heat.

When a body is electrified it acquires a certain power of doing work, called *electric potential.* Electric potential is measured in units called *volts.* The path through which an electric discharge passes is called the *circuit.* All circuits offer a measurable resistance to the passage of an electric discharge. Electric resistance is measured in units called *ohms.*

The rate at which electricity passes through a circuit is called the current, and is measured in units called *ampères.* An ampère is the current which would pass in a circuit whose resistance is one ohm, under a potential of one volt.

Though electricity is probably not a fluid, yet it resembles a fluid in many respects, and the units already referred to are, to a certain extent, based on this resemblance. The quantity of liquid that flows through a pipe in a given time depends on the pressure on the liquid, and the resistance offered by the pipe. The quantity-per-second corresponds to the ampères; the pressure which causes the flow, to the volts; and the resistance which limits the flow, to the ohms.

Electricity may be produced in bodies by a variety of causes: such as *friction, heat, chemical action, magnetism, and animal or vegetable life.*

There are two distinct forms of electrical excitement: the *positive* and the *negative.* A body with a high potential is generally assumed to be positively charged; one with a low potential, negatively charged. The current is assumed to flow from the higher to the lower potential, or from the positive to the negative. Bodies charged with electricity of the same kind, repel one another; if charged with different kinds, they attract, and if the bodies are free to move, they approach, when the opposite excitements neutralize each other. In case the electrical excitement is considerable, the union is accompanied by a sharp crack, and a flash of light, called *the electric spark*.

291. Conductors of electricity are bodies which allow its ready passage through them. Metals, charcoal, acids, aqueous solutions, and various animal and vegetable substances, are good conductors. *Non-conductors* are those which do not allow the electricity to flow freely through them. Gums, resins, glass, silk, and dry air are non-conductors.

The higher the conducting power of a circuit the lower will be its resistance, and, consequently, the greater the current which will be sent through it by a given potential.

292. Atmospheric Electricity.—Electric excitement is always present in the atmosphere. The electricity of the air is generally positive, although it often changes rapidly to negative on the approach of clouds or fogs. It is feeblest within a few feet of the surface, and increases with the elevation above the general surface of the earth.

Origin of Free Atmospheric Electricity.—The electricity of the atmosphere is caused by a variety of circumstances, the chief of which are evaporation and condensation; unequal heating of the earth by the sun's rays; combustion; animal and vegetable life; and the friction of winds against each other or against the earth's surface.

293. Lightning occurs when the electricity of a cloud discharges to the earth or to a neighboring cloud. The discharge is attended by a vivid spark, called lightning. The destructive effects of lightning are due to the discharge between the clouds and the earth.

Thunder.—The heat of the spark vaporizes the rain-drops, and enormously expands the air, producing, on their subsequent cooling, a partial vacuum, which is further increased by the momentary pushing aside of the air by the discharge. The surrounding air rushing violently into this vacuum produces the sound called thunder.

The potential of the lightning flash is enormously higher than that produced by artificial means, and must be equal to many millions of volts. This high potential is due to the enormous decrease in the surface of a single rain-drop from the thousands of smaller drops which have coalesced to form it.

294. Varieties of Lightning.—There are five varieties of lightning: *zig-zag or chain, sheet, heat, globular, and volcanic lightning.*

Zig-zag Lightning probably owes its forked shape to the resistance which the air offers to its passage through it. The air-particles, being crowded together in the path of the spark, the lightning darts to one side, where the air is less dense.

Sheet Lightning generally accompanies thunder-storms, and appears as an expanded flash, which illumines the clouds.

Heat Lightning, *or lightning without thunder*, is generally seen near the horizon, during hot weather. It is probably caused by the reflection of lightning from a storm below the horizon.

Globular Lightning. On rare occasions, the lightning appears in the form of a globe of light, which remains stationary in the air or moves slowly through it. Its cause is unknown.

Volcanic Lightning. During the eruption of volcanoes, vivid flashes of lightning often occur in the air near the craters. Volcanic lightning is probably caused by the rapid condensation of the vast volumes of vapor emitted with the ashes and lava.

295. Lightning Rods, invented by Franklin, protect the buildings on which they are placed, by quietly discharging the electricity from the overhanging cloud. They generally effect this by an opposite electricity passing from the earth up the rod, and neutralizing that of the cloud. Unless the rods are placed in good metallic connection with the earth, and with all conductors near them, they are sources of danger rather than of protection.

296. St. Elmo's Fire.—When the atmosphere is highly charged with electricity, faint tongues of fire are often seen on the ends of bodies in

Fig. 99. St. Elmo's Fire.

connection with the earth, like the masts of ships, steeples, etc., due to an electric discharge, known as the *brush-discharge*. They are called St. Elmo's fire, and are harmless.

297. The Aurora Borealis, or northern light, is a phenomenon of marvellous beauty, occurring in the sky of high latitudes in both the northern and southern hemispheres. It appears in a variety of forms; at times huge pillars of fire move rapidly across the heavens, or the entire northern sky is lighted as by a drifting storm of luminous snow. The commonest appearance, however, is that of an arch of fire, from which streamers flash toward the zenith.

Auroras are most frequent in high latitudes, though not in the *immediate vicinity* of the poles.

Auroras are caused by the passage of electricity through the rare air of the upper regions. The proofs are as follows: During the continuance of an aurora, the telegraph wires show the presence of an unusual electrical disturbance, and the magnetic needle is subject to frequent oscillations; moreover, the same phenomena can be produced by the passage of an electrical current through rarefied gases, as in the Geissler tubes—different colors arising from its passage through different gases.

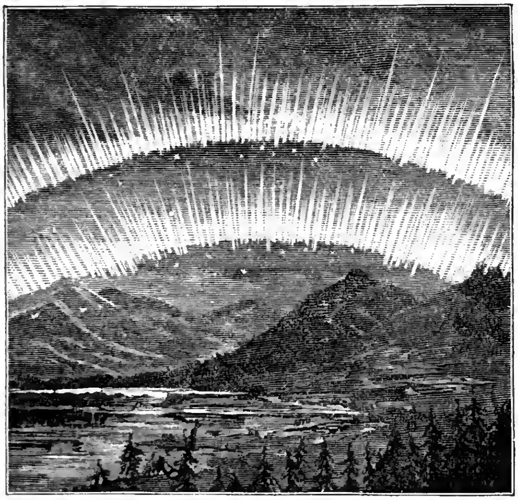


Fig. 100. Aurora Borealis.

298. Magnetism.—The recent researches of Herz leave little doubt that electro-magnetic phenomena are due to a wave motion in the luminiferous ether.

Magnets are bodies which have the power of attracting particles of iron or the opposite poles of other magnets.

All magnets possess an atmosphere of influence surrounding them, called the *magnetic field*. The magnetic field is traversed by *lines of force*, which come out of the magnet at one point and enter it at another, thus forming a *magnetic circuit*. The points where the lines come out are called poles; the former being the *positive* or *north pole*, and the latter the *negative* or *south pole*.

Magnets are either *natural* or *artificial*. Natural magnets are found in lodestone, a species of iron ore composed of oxygen and iron. Pieces of hardened iron or steel may be magnetized, by rubbing them with a lodestone, or by passing electrical currents around them, thus forming what are called *electro-magnets*. All magnetizable substances become magnetized when they are brought into a magnetic field.

If a magnetized bar or needle be suspended at its centre of gravity so as to move freely in a horizontal plane, after a few oscillations it will come to rest, with one of its ends pointing nearly to the geographical north pole of the earth. This end of the magnet is called its *north pole*, the opposite end its *south pole*, and the magnet itself, a *magnetic needle*.

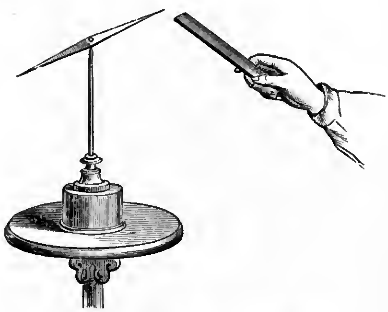


Fig. 101. The Magnetic Needle.

299. Magnetic Attractions and Repulsions.—If a magnet is brought near a magnetic needle, attraction or repulsion will ensue—*repulsion, when the poles are of the same name; attraction, when they are of opposite names.* Thus, when a north pole is approached to a north pole, or a south pole to a south pole, they repel each other; but when a north pole is approached to a south pole, or a south pole to a north pole, they attract. If the approaching magnet is powerful, it will deflect the magnetic needle, although several feet distant from it; and if placed permanently in this position, the magnetic needle *will no longer point to the north, but will turn toward the disturbing magnet.*

300. Cause of the Magnetic Needle pointing to the Geographical North.—The magnetic needle points to the north for the same reason that the opposite poles of magnets point to each other when they are sufficiently near. *The entire earth acts as one huge magnet, with its poles in the neighborhood of the extremities of its axis,* and the magnetic needle points toward these poles on account of their attraction.

The earth, like all magnets, possesses a magnetic field. Lines of magnetic force come out of its north pole, pass around the earth through the air, and enter the earth at its south pole. A magnetic needle, placed in the earth's field, if free to move, will come to rest with the earth's lines of force passing into its south pole and passing out of its north pole. That pole of the needle which points to the geographical north is, therefore, of opposite magnetic polarity to the earth's polarity in the Northern Hemisphere. In the United States, the Northern Hemisphere is regarded as possessing *south* magnetic polarity; in France, as possessing *north* magnetic polarity.

301. Origin of the Earth's Magnetism.—The exact cause of the earth's magnetism is unknown. Currents of electricity circulating around a conductor render it a magnet. Electrical currents are generated in nearly all substances, when they are unequally heated. The earth appears to owe its magnetism to the circulation around it of currents of electricity, produced, most probably, by the unequal heating of different portions of its surface by the sun's rays. These currents would follow the sun in its apparent motion from east to west. Since the earth's magnetism appears to have its remote cause in the sun's heat, variations in the temperature should be followed by corresponding variations in the intensity of magnetism. This is found to be the case.

Magnetic storms, or unusual variations in the earth's magnetism, have been noticed to correspond with outbursts of solar activity, as manifested by the unusual occurrence of new spots.

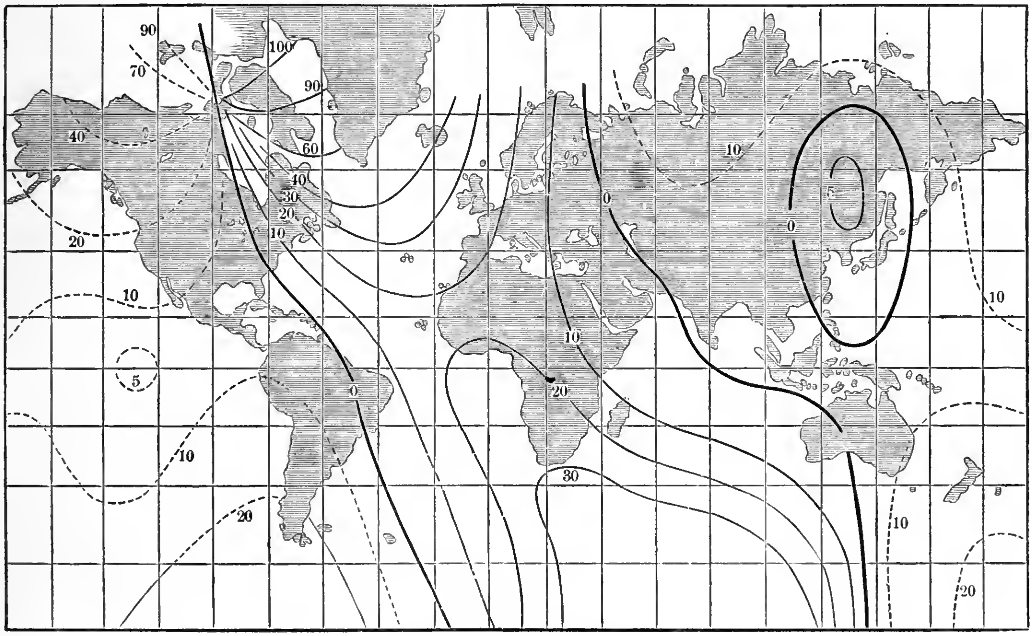


Fig. 102. Declination Chart.

(West Declination is represented by the continuous lines; East Declination by the dotted lines; the Agones by the heavy lines.)

302. The Declination or Variation of the Needle.—The earth's magnetic poles do not correspond with its geographical poles. The magnetic needle, therefore, except in a few localities, does not point to the true geographical north, but to the east or to the west of it. This deviation from the true north is called the *declination* or *variation*, and is *east* or *west* according as the needle points to the east or the west of the true or geographical north. The amount of this variation differs in different parts of the earth.

The position of the magnetic poles of the earth is not always the same, but changes slowly from year to year, thus producing corresponding changes in the declination of the needle. This change is called *secular variation.* The needle, at any place, points more and more to the east, following the change of the poles. At length, after a long period, it becomes stationary, and then begins to move toward the true meridian, which it at length reaches; when, continuing its motion, the declination becomes west.

Isogonal Lines.—Lines connecting places which have the same declination, are called *isogonal lines.* Lines connecting these places, when the needle points to the true north, are called *agones,* or lines of no declination.

The direction of the isogonal lines is shown in the declination chart, the figures near the lines giving the value of the declination in degrees. The agone in each hemisphere is marked 0. In the New World it enters South America near Rio Janeiro, curves to the eastward around the Antilles, passes near Washington, through the western part of Hudson Bay, and enters the magnetic pole at Boothia Felix. The agone, in the Old World, passes through the west of Australia, near the western coasts of Hindostan, through Persia, the eastern part of the Caspian Sea, and through the White Sea, in Europe. The oval curves in Eastern Asia seem to indicate a secondary magnetic pole.

In nearly all Europe, in the whole of Africa and Arabia, in eastern North and South America, and in nearly all the Atlantic and Indian Oceans, the declination is *west*. It is also west along part of the eastern shores of Asia, around the secondary magnetic pole. In the remainder of the world the declination is *east*.

303. The Inclination or Dip of the Needle.—The lines of force of the earth's magnetic field are in most places inclined to the earth's surface. The position of the needle is, therefore, horizontal in but a few localities. In most places, one of the poles is inclined to the earth. This is called the *inclination* or *dip of the needle*. In the Northern Hemisphere, it is the north pole, and in the southern, the south pole that is inclined.

304. Magnetic Equator.—The angle of dip is greater, the nearer we approach either magnetic pole. At the pole, the needle points vertically downward; midway between the poles, the needle is horizontal; the last position is called the *magnetic equator*.

Lines connecting places which have the same angle of dip are called *isoclinal lines*. They correspond in a very remarkable manner with the isothermal lines. This seems to show the dependence of the intensity of magnetism on the distribution of the sun's heat. The *inclination* is also subject to secular changes, like the *declination*.

305. Optical Phenomena are caused by changes in the direction, intensity, or composition of sunlight during its passage through the atmosphere.

Sunlight, when passed through a prism, is dispersed or separated into a great number of different colored lights. The following seven groups of colors are prominent: *violet, indigo, blue, green, yellow, orange, and red*. These are called the prismatic colors, or, collectively, a spectrum. They differ in the ease with which they are *refracted*, or turned out of their course, in passing from one medium to another of different density. The above prismatic colors seen in the spectrum are named in the order of their refrangibility, beginning with the violet, the most refrangible, and ending with the red, the least refrangible.

306. Rainbows are arches of the prismatic colors, caused by the dispersion of the light during its passage through the falling drops of rain. The rays entering the drop, are reflected from the surfaces farthest from the sun, and emerge separated into the prismatic colors.

Rainbows are seen when the observer stands with his back toward the sun. They are largest when the sun is nearly setting.

A secondary bow sometimes occurs outside the primary, with the order of its colors reversed. It is caused by the light which is twice reflected from the back of the drops.

307. The Sunset Tints of the Sky are *yellow, orange, and red*. The rays of the setting sun are dispersed, during their passage through the clouds, or through accumulations of vapor at the horizon, and only the colors that are least turned out of their course, the yellow, the orange, and the red, pass through and light up the western sky.

308. The Blue Color of the Sky is caused by the diffusion through the air and their subsequent reflection from its particles of the more refrangible rays of light: the indigo and the blue.

309. Halos and Coronæ are rings of prismatic colors surrounding the sun and moon.

Halos are caused by the presence in the air of small crystals of ice or snow. *Parhelia*, or mock suns, and *Paraselenœ*, or mock moons (bright spots which somewhat resemble suns and moons), are frequently seen where the complicated circles of halos intersect each other. *Coronœ* are circles of light, seen most frequently around the moon. They are caused by the presence of a small quantity of condensed vapor in the air. They generally indicate changes in the weather.

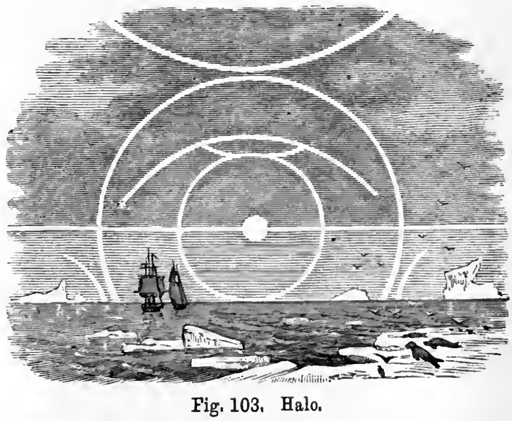


Fig. 103. Halo.

310. The Mirage is a general term applied to the appearance which objects present when viewed by means of rays of light that have passed through strata of air, which gradually increase or decrease in density. In this way the objects appear either inverted or erect, but always out of their true position. Sometimes the objects are repeated, one being seen above the other. The mirage occurs both over water and land. It is caused by the turning of the rays of light out of their original direction.

The Mirage of the Desert occurs over hot, arid surfaces, whenever the strata of air increase rapidly in density from the surface upward. The rays of light from distant objects, such as trees, are reflected from one of the lower layers of air, and, entering the eye of the observer, appear to come from inverted objects, which seem to be surrounded by a sheet of water. The image of a real tree is seen, but out of its true situation, so that when the observer reaches the place he finds nothing.

The mirage frequently occurs on the sea. Vessels that are too far below the horizon to be directly visible, become visible by refraction. This phenomenon is called *looming*. The vessels are seen both erect and inverted, and sometimes appear suspended in the clouds. Distant islands are sometimes visible from the same cause.

SYLLABUS.

The rapidity of evaporation increases—1. With the temperature of the atmosphere. 2. With the extent of surface exposed. 3. With a decrease in the quantity of vapor already in the air. 4. With the renewal of the air; and, 5. With a decrease of the pressure on the surface.

When air can hold no more moisture in an invisible state, it is said to be *saturated* or at its *dew point.*

Whenever the air is lowered below the temperature of its dew point, its moisture is deposited as cloud, mist, snow, hail, sleet, or rain.

More dew falls on clear nights, when the wind is moderate, than on cloudy nights, when the wind is high.

In fogs, mists, and clouds, the moisture is condensed as minute drops.

Clouds owe their variety of forms to the action of aërial currents, and their constant tendency to settle.

The dense fogs so common off the banks of Newfoundland are caused by the chilling of the warm, moist air of the Gulf Stream by the cooler air of the Labrador current.

The primary forms of clouds, are the cirrus, the cumulus, the nimbus, and the stratus.

The secondary forms of clouds, are the cirro-stratus, the cirro-cumulus, and the cumulo-stratus.

Rain falls whenever the temperature of a *mass* of air is lowered considerably below the temperature of its dew point.

This reduction of temperature may occur—1. By a change of altitude by means of ascending currents. 2. By a change of latitude, as by the warm equatorial currents flowing into colder regions nearer the poles. 3. A comparatively small rainfall may be caused by the intermingling of moist cold and moist warm air.

As a rule, the equatorial currents bring rain, the polar currents, drought.

In the zone of calms, it rains during the hottest part of the day, or in the afternoon, when the ascending currents are strongest.

In the zone of the trades, it rains during the hottest part of the year, or in summer.

Between lat. 24° and 30°, both N. and S., the rainfall is scanty, and in some localities almost absent.

In the zone of the variables, it may rain at any hour of the day or night, or at any time of the year.

In the polar zones, the winters are clear; snows and drizzling rains occur in spring and autumn.

Between lat. 30° and 35°, both N. and S., it is dry in summer during the prevalence of the polar currents. The rest of the year is wet.

The rainfall of any place is determined by means of an instrument called a rain-gauge or pluviometer.

An inch of rain on the surface of a square yard is equal in weight to 46.75 pounds; an inch on the surface of an acre, to the weight of about 100 tons.

The quantity of rain decreases from the equator to the poles, and from the coasts of the continents toward the interior.

More rain falls on mountains than on plains; more on plains than on plateaus; more in the Northern Hemisphere than in the Southern.

In the tropics of the New World, the annual rainfall is 115 inches; in the Old World, only 77 inches.

In the temperate regions of the New World, the annual rainfall is 35 inches; in the Old World, but 34 inches.

The average rainfall of Europe, between lat. 36° and 60° N., is 34 inches.

The average rainfall in the United States, between 24° 30′ and 45° north latitude, is 39 inches.

The desert belt of the eastern continent extends from the western shores of Northern Africa eastward to the Great Kinghan Mountains in Asia. It includes the Sahara, the Arabian and Persian Deserts, and the Desert of Mongolia. The aridity of this immense tract is caused by the absence of rain.

The desert tracts near the summits of high mountains are caused by the absence of heat and liquid moisture.

Hail falls when bodies of warm and intensely cold air are rapidly commingled.

Snow falls when the moisture is condensed at temperatures at or below 32° Fahr., under conditions favorable to gradual crystallization while the moisture is condensing. Sleet is frozen rain.

The snow line is the distance above the sea where snow remains throughout the year.

The snow line in the tropics is found at about three miles above the level of the sea; in the temperate regions, at rather less than two miles; near the northern extremities of the continents, at less than one mile; while still farther north, on the polar islands, it is but a few hundred feet above the sea.

The height of the snow line, depends—

(1.) On the amount of the snowfall.

(2.) On the temperature of the valley.

(3.) On the inclination of the slopes.

Glaciers are immense masses of ice, formed by the snow which accumulates on the slopes of mountains above the snow line. They move slowly by gravity down the mountain slopes, bearing with them accumulations of dirt and stones, called *moraines.*

The upper surface of the glacier is generally broken into deep fissures, called *crevasses.*

The water derived from the melting of the glacier issues in a stream from the lower end of the ice mass. It is highly charged with sediment derived from the erosion of the glacier. It often forms the source of a powerful river.

The following mountains contain glaciers: the Alps, the Pyrenees, the Caucasus, the Scandinavian Mountains, the Himalayas, and the Karakorum.

When glaciers descend into the sea, the waters undermine them, and detach huge masses, which float away to great distances. These masses are called *icebergs.*

Toward the close of the Mammalian Age, a change occurred in the climate of the earth, by which all the northern continents were covered with glaciers.

The unit of electric potential is called a *volt;* the unit of current is called an *ampère;* the unit of resistance is called an *ohm.*

Comparing the flow of electricity to that of a current of water in a pipe, the volt corresponds to the pressure causing the flow, the ohm to the friction or other resistance opposing it, and the ampère to the quantity of the flow per second.

The free electricity of the air is generally positive.

Lightning results when the electricity of a cloud discharges to the earth, or to a neighboring cloud.

There are five kinds of lightning: zig-zag, heat, sheet. globular, and volcanic.

When the air contains an unusually great quantity of electricity, faintly luminous balls are seen on the ends of tall objects. These are called St. Elmo's fire.

Auroras are caused by the passage of electricity through the rare air of the upper regions of the atmosphere.

The earth acts like a huge magnet. It possesses a magnetic field, and has lines of force entering its south pole in the Northern Hemisphere, and coming out of its north pole in the Southern Hemisphere.

A magnetic needle, if free to move, will come to rest in the earth's field with the lines of force of the earth passing in at its south pole and coming out at its north pole.

The magnetic needle points to the north, from the action of the magnetic poles of the earth. The cause of the earth's magnetism is not certainly known. It is probably due to electrical currents which circulate around it.

Magnetic storms, or unusual variations in the earth's magnetism, correspond with outbursts of solar activity as manifested by sun-spots.

The deviation of the needle from the true north, is called its *declination;* the deviation from a horizontal plane, its *inclination.* Both declination and inclination are subject to diurnal, annual, and secular variations.

Isogonal lines connect places which have the same declination. Isoclinal lines connect places which have the same inclination. Isoclinal lines are nearly coincident with the isothermal lines.

Rainbows are caused by the action of light on falling raindrops.

Halos are caused by snow crystals in the air; *Coronæ,* by minute particles of water.

The Mirage is caused by the bending of the rays of light from their original direction, while passing from one medium to another of different density.

REVIEW QUESTIONS.

What do you understand by evaporation?

Name the circumstances upon which the rapidity of evaporation depends.

Define dew point.

What condition is necessary in order that the invisible moisture of the atmosphere may become visible in any form of precipitation?

Under what circumstances is dew deposited?

Why is more dew deposited on a clear night than on a cloudy night? Why is more dew deposited on a still night than on a windy one?

Under what circumstances are fogs, or mists, produced? How do fogs or mists differ from clouds?

What is the condition of the particles of water which form the clouds? Are they minute drops, or hollow vesicles?

Describe the appearance of the cirrus cloud. How does its height compare with that of other clouds?

During what parts of the day are stratus clouds most common? To what do they owe their banded appearance?

Describe the cumulus cloud. During what part of the day is it most common?

Why should the cirro-stratus clouds generally indicate approaching rain?

Name three conditions under which rain may be caused. By which are the heaviest rains generally produced?

Are the equatorial currents likely to bring rain or drought? The polar currents? Why?

Name the periodical rain zones.

When does it rain in the zone of calms? In the zone of the trade winds? Why?

In what portions of the zone of the variable winds is the rainfall approximately periodical?

Describe the rainfall in the zone of the variable winds. In the zone of the polar winds.

Describe the construction of a rain-gauge or pluviometer.

Why should more rain fall on a mountain than on the lowlands at its base? Why should more rain fall on the coasts of a continent than in the interior?

Compare the mean annual rainfall of the tropics of the Old and New Worlds. Of the temperate regions of the Old and New Worlds.

Name the rainless districts of the Eastern Continent. Of the Western Continent.

What is the cause of the almost total absence of rain in these districts?

Under what circumstances is hail produced?

Describe the structure of a hailstone.

Explain the rotary theory of hail.

Define the snow line. Upon what does the height of the snow line depend? At what height above the sea-level is it found in the tropics? In the temperate regions? In the polar zones?

How are glaciers formed? In what respects do they resemble rivers?

What are crevasses? How are they formed?

Name some rivers which take their origin in the melting of glacial ice.

Define lateral moraines; medial moraines; terminal moraines.

Explain the manner in which fiord-valleys were formed. What is the probable origin of lakes in all glacier districts?

Name some of the European mountain systems which contain extended glacier regions. Name two Asiatic mountain ranges which contain such regions.

How are icebergs formed? Is the ice of which they are composed salt or fresh?

What are ice floes? State their origin.

What appears to have been the southern limit of the glaciers in the United States, during the glacial epoch, which occurred toward the close of the Mammalian Age?

What is the origin of free atmospheric electricity?

Define volt; ohm; ampère; potential; circuit.

Under what circumstances does lightning occur? What is the cause of the accompanying thunder?

Name five varieties of lightning.

By what are auroras caused?

What is the cause of the directive tendency of the magnetic needle?

What is believed to be the cause of the earth's magnetism?

What do you understand by the earth's magnetic field?

Define isogonal lines; isoclinal lines.

With what lines are the isoclinal lines nearly coincident?

Explain the phenomenon of the rainbow.

What is the cause of the sunset tints of the sky? Of the blue color of the sky?

What are halos and coronæ? By what are they caused?

Explain the cause of the mirage of the desert.

What do you understand by the phenomena of looming?

MAP QUESTIONS.

Trace on the map of the winds and rains, the portions of the world included in the zone of calms. When does it rain in the zone of calms?

Trace in a similar manner the portions included in the zones of the trades, and the zones of the variables. What is characteristic of the rainfall in each of these zones?

Why should the eastern shores of tropical South America be moist, and the western dry?

To what peculiarity of position does Northern Africa owe its scanty rainfall?

Trace on the map of the isothermal lines the southern limit of the Arctic drift ice; the northern limit of the Antarctic drift ice.

Trace on the declination chart, the agone, or line of no declination, in the Western Hemisphere.

Trace the line of no declination in the Eastern Hemisphere. What smaller line of no declination exists in this hemisphere?

Notice that in the Western Hemisphere the isogonal lines all meet in a point near Hudson Bay. What does this meeting indicate?

PART V.

ORGANIC LIFE.

THE variety and luxuriance of life found on the surface of the earth are far greater than is at first apparent. Besides the larger species of animals and plants, myriads of microscopic forms inhabit the land, the water, and the air. From the burning sands of tropical deserts, to the eternal snows of the poles, widely differing forms occur, each being peculiarly fitted for its own conditions of growth.

An organic form differs in many respects from one that is inorganic. The animal or plant has its origin in a germ; grows from nourishment taken into its structure; has a regular development in growth, passing, by successive stages, from birth to maturity, when it reproduces its kind, and passes on to decay and death.

A crystal, which may be taken as the type of the inorganic world, grows by additions from without, does not reproduce its kind, has no regular development or growth, being perfect from its first existence, and has no decay or death.

SECTION I.

PLANT LIFE.

CHAPTER I.

Plant Geography.

311. Living Matter.—All life, whether vegetable or animal, consists of various groupings of cells, or approximately spherical masses, consisting of a peculiar form of jelly-like matter called *protoplasm,* composed of various complex combinations of carbon, hydrogen, oxygen, and sulphur, called *proteids.* At its beginning all life consists of a minute germ cell, filled with more or less transparent protoplasm, and containing a darker opaque spot called the *nucleus*. Examined by a sufficiently powerful glass, all living protoplasm is seen to be in constant motion, currents passing through the different parts in somewhat definite directions.

As the germ cell develops, in all the higher forms of life, it multiplies, and various organs appear, peculiar to the form of life from which the germ cell was derived. All living bodies contain organs, and living matter is therefore sometimes called *organic matter*, to distinguish it from non-living or *inorganic matter*.

Science has not yet disclosed the nature of the change whereby non-living matter is converted into living protoplasm. To produce living matter the intervention of already living matter is, so far as is known, absolutely necessary.

312. Intermediate Position of Plants.—Protoplasm forms an essential part of both plants and animals. Plants alone, however, possess the power of manufacturing protoplasm directly from inorganic or non-living matter. Plants prepare food for animals, who are, consequently, dependent on plants for their existence. Both plants and animals are *consumers* of the proteid compounds. Plants alone are *producers*. In the scale of existence plants, therefore, occupy a position intermediate between minerals and animals.

313. Plant Geography treats of the distribution of plant-life over the earth.

Plant geography differs essentially from botany. *Botany* arranges plants into regular classes, according to peculiarities in their organs of growth and reproduction. *Plant geography* considers them only in reference either to the more prominent appearances, by which they give a distinct character to the vegetation of a country, or in regard to their general usefulness to man.

In this limited view, all the minuter differences in structure or organization are passed over, *the general form* being the main geographical element of a plant, and the element with which physical geography is principally interested.

The plants of any section of country, taken collectively, are called its *flora*.

314. Conditions Requisite for Plant Growth.—Plants require for their growth certain conditions of *light, heat, and moisture;* and since the requisite amount of each of these varies with different species of plants, we find in every climatic zone a characteristic flora. *The soil* must contain those mineral ingredients which form a part of the structure of the plant, and, moreover, must contain them in a condition in which they can be readily assimilated by the plant.

The substance of plants consists mainly of water derived from the air and the soil. Analysis shows that vegetable matter is composed almost entirely of water, and various compounds of carbon, hydrogen, oxygen, and sulphur. The water is derived from the moisture of the soil and of the air; the carbon, from the carbonic acid of the air. The exceedingly small proportion of mineral matter comes directly from the soil.

The nature of the soil, then, is far from being the most important element in the distribution of mere vegetation; for, even when a soil is absent, if the other requisites of light, heat, and moisture are present, the simpler vegetable forms soon appear, and slowly prepare, even on a bare, rocky surface, a soil which is able to sustain higher and still higher species. This is effected by the breaking up of the hard mineral matter, and the accumulation, year after year, of the decaying plants. In this way a *vegetable mould* is produced. The bare surfaces which the continents possessed, when they first emerged from the oceans, gained their covering of soil principally in this way.

Moisture, Heat, and Light are the prime essentials of vegetation, and it is on their distribution that the distribution of vegetation is principally dependent.

315. Distribution of Vegetation.—The influence of heat and moisture is noticed as we pass from the equator to the poles, or from the base of a tropical mountain to the summit. Thus arises a *horizontal and a vertical distribution of vegetation.*

The greatest luxuriance of vegetation is found in the equatorial regions, where both heat and moisture are most abundant. Here a greater variety of species occurs, and the individual plants are larger, and more brilliantly colored, both in their leaves and flowers. As we pass toward the poles, the number of the species diminishes; trees disappear, being replaced by shrubs and herbs, and these, in turn, by lichens and mosses, until finally, amid the snows of the polar latitude, even the simplest forms of vegetable life are often wanting.

316. Horizontal Distribution of Vegetation.

(1.) **According to Meyen,** we may divide the earth's surface into zones according to the latitude, and the mountainous elevations into zones according to the altitude. Since the distribution of heat is not only dependent on the latitude or altitude, we may advantageously modify this plan as has been suggested by Dove, and divide the zones by the isotherms.

(2.) **According to Schouw,** we may divide the earth's surface into regions characterized by assemblages of peculiar floras, and separated by natural barriers.

The great number of the regions required to give thoroughness to Schouw's system, renders its use inadvisable in an elementary book.

(3.) **According to Humboldt and others,** we may divide the earth's surface into zones, according to the physiognomy of the plants inhabiting them. Here plants of entirely different species are grouped *by their mere outward resemblances* into what are called *forms.*

The first method is the one most suitable for our purposes. We shall follow, in the main, Dove's modification, as adopted by A. R. Johnston, and divide the surface of the earth into zones, according to the *isotherms,* or lines of mean annual temperature. The values of the isotherms are given in round numbers. This system is based on the fact, that the character of the vegetation is dependent mainly on the temperature, which, in its turn, regulates the quantity of moisture.

317. Horizontal Zones of Vegetation.

(1.) The Tropical Zone, extends between the isotherms of 73° Fahr. on each side of the equator.

(2.) The Sub-Tropical Zones, extend in each hemisphere from the isotherm of 73° Fahr. to 68° Fahr.

(3.) The Warm Temperate Zones, extend in each hemisphere from the isotherm of 68° Fahr. to 55° Fahr.

(4.) The Cold Temperate Zones, extend in each hemisphere from the isotherm of 55° Fahr. to 41° Fahr.

(5.) The Sub-Arctic Zone, extends in the northern hemisphere from the isotherm of 41° Fahr. to the September isotherm of 36.5° Fahr.

(6.) The Polar Zone, extends in the northern hemisphere from the September isotherm of 36.5° Fahr. to the poles.

318. The Tropical Zone, or the zone of *palms, bananas, spices, and aromatic plants,* lies on each side of the equator, between the isotherms of 73° Fahr. It includes most of the land within the tropics of both hemispheres.

The excessive heat and moisture of this zone produce an especial luxuriance in the vegetation. Trees attain enormous size, the foliage is bright, the flowers brilliant, and the number of species great. The forests are characterized by the great variety of trees, and when allowed to attain their densest growth, are almost impenetrable, from the numerous parasitic plants with which they are covered, or the gigantic, rope-like climbers that twine among them.

Palms, bananas, tree-like grasses, and orchids are among the most characteristic plants.

Orchids are curious plants, inhabiting damp forests. They attach themselves to trees and rocks, drawing nearly

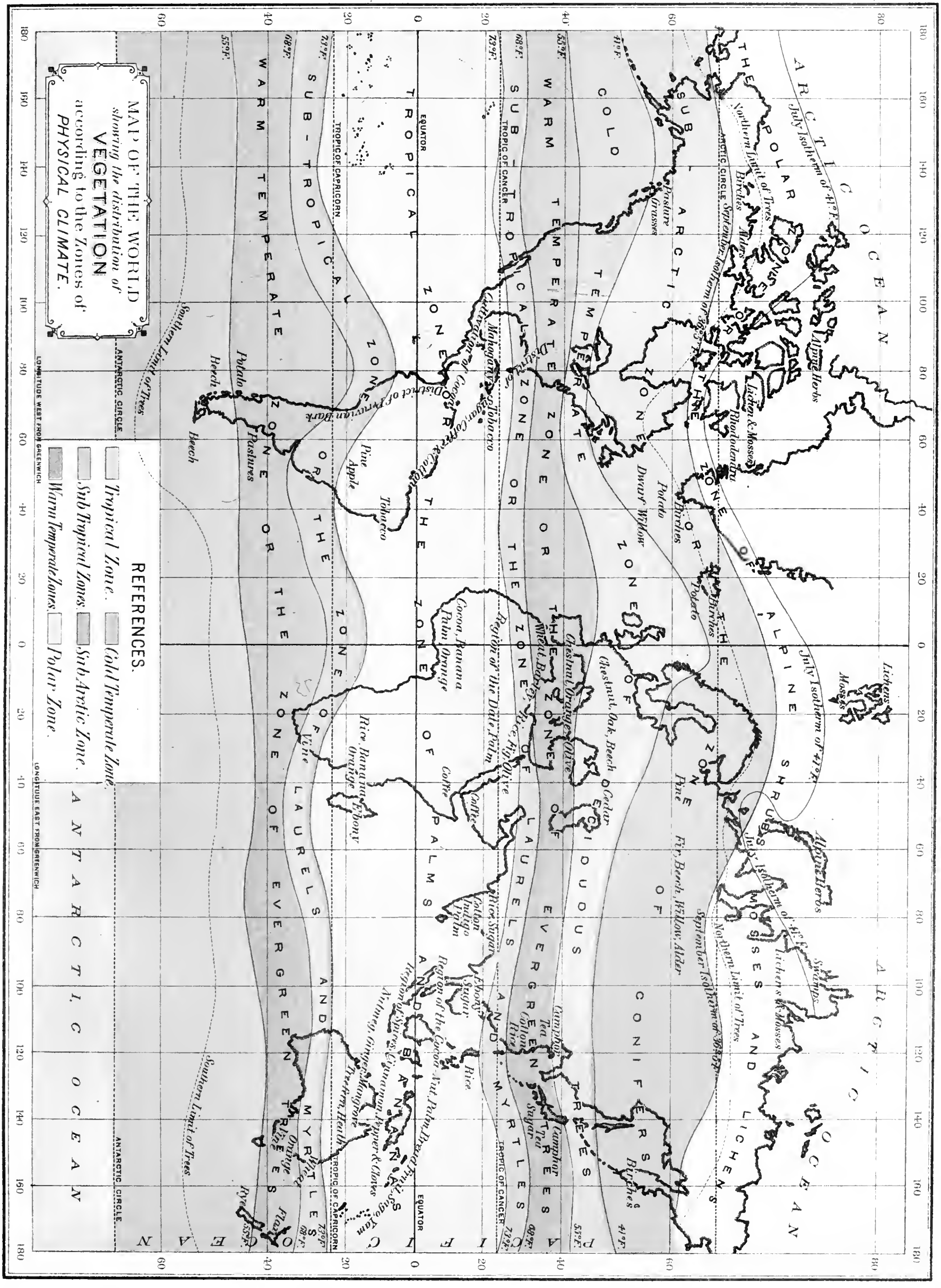
Fig. 104. Palm-Trees.

all their nourishment from the air. As a class, they are noted for the fragrance, vivid coloring, and curious forms of their flowers. The well-known vanilla bean is obtained from an orchid. The humble grasses of our latitude, in this zone, are represented by the bamboo, which often attains the height of 60 feet.

The banyan-tree, a species of fig-tree, is found in the

Fig. 105. Banyan-Tree.

East Indies. From a colossal trunk numerous air-branches are sent out, which, descending to the ground, take root,


MAP OF THE WORLD
showing the distribution of
VEGETATION
according to the Zones of
PHYSICAL CLIMATE.
REFERENCES.
Tropical Zone.
Cold Temperate Zone.
Sub Tropical Zones.
Sub Arctic Zone.
Warm Temperate Zones.
Polar Zone.
ARCTIC OCEAN
ANTARCTIC OCEAN
PACIFIC OCEAN
POLAR ZONE
ALPINE SHRUBS MOSSES AND LICHENS
SUB-ARCTIC ZONE OR THE ZONE OF BIRCHES
COLD TEMPERATE ZONE
ZONE OF DECIDUOUS TREES
ZONE OF CONIFERS
WARM TEMPERATE ZONE OR THE ZONE OF EVERGREEN TREES
SUB-TROPICAL ZONE OR THE ZONE OF LAURELS AND MYRTLES
TROPICAL ZONE OR THE ZONE OF PALMS AND BANANAS
SUB-TROPICAL ZONE OR THE ZONE OF LAURELS AND MYRTLES
WARM TEMPERATE ZONE OR THE ZONE OF EVERGREEN TREES
July Isotherm of 41°F.
September Isotherm of 36°5°F.
Northern Limit of Trees
Southern Limit of Trees
ARCTIC CIRCLE
TROPIC OF CANCER
EQUATOR
TROPIC OF CAPRICORN
ANTARCTIC CIRCLE
LONGITUDE WEST FROM GREENWICH
LONGITUDE EAST FROM GREENWICH
Lichens & Mosses
Alpine Herbs
Rhododendra
Birches
Alders
Pasture Grasses
Potato
Dwarf Willow
Pine
Fir, Beech, Willow, Alder
Chestnut, Oak, Beech
Cedar
Chestnut, Orange, Olive
Wheat, Barley, Rice, Fig, Olive
Region of the Date Palm
Camphor
Tea
Cotton
Rice
Sugar
Cultivation of Mahogany & Tobacco
Cultivation of Sugar, Coffee & Cotton
District of Peruvian Bark
District of Cocoa
Cocoa, Banana
Palm, Orange
Rice, Banana
Orange
Ebony
Coffee
Indigo
Region of the Cocoa-Nut Palm, Bread Fruit, Sago, Yam
Region of Spices, Cinnamon, Pepper & Cloves
Nutmeg, Ginger, Mangrove
Tree Fern, Heath
Pine Apple
Tobacco
Pastures
Beech
Vine
Orange
Flax
Rye

and in their turn send out other branches, and in this way an extended area is covered. A single tree has been known sufficiently large to give shade to 7000 men at the same time.

The Llanos of the Orinoco are found in the tropical zone. During the dry season, they are almost entirely devoid of vegetation; but during the wet season, they are covered with grasses.

The Indian Archipelago affords an excellent illustration of the wonderful luxuriance of the vegetation of the tropics. Here the gigantic Rafflesia bears flowers three feet in diameter!

In the northern and southern portions of the tropical zone, where the mean annual temperature ranges from 79° to 73° Fahr., the vegetation, though similar to that of the equatorial regions, begins to lose its density and luxuriance. The forests contain less undergrowth and fewer parasitic plants. Tree-like ferns and figs are especially abundant, and some authorities have arranged these portions into separate zones, called the zones of tree-ferns and figs.

319. The Sub-Tropical Zones, or the Zones of Laurels and Myrtles, extend in each hemisphere, from the isotherm of 73° Fahr. to 68° Fahr. Here, the heat of summer, though sufficient to ripen most of the tropical fruits, is not as intense as in the tropical zone. The winters are mild, and scarcely arrest the vegetation. The palms and bananas of the preceding zones are still common, but *the characteristic vegetation is found in the abundance of trees with thick, shining leaves, such as the laurels, magnolias, and myrtles.*

320. The Warm Temperate Zones, or the Zones of Evergreen Trees, or trees which do not shed their leaves, extend in each hemisphere, from the isotherm of 68° Fahr. to 55° Fahr. In this zone, trees with thick, shining leaves occur, mingled with oaks, beeches, and others similar to those found in our own forests. No palms occur, but in their place we find a number of glossy-leaved evergreen trees, and handsome evergreen shrubs.

In those portions of this zone which are in the neighborhood of the Mediterranean, the bay, myrtle, laurel, fig, and the olive, are characteristic. The cork oaks, chestnuts, and pomegranates, are frequent. The vine, said to be a native of this zone, attains here its greatest growth, the stem often reaching a thickness of half a foot. In America, oaks, pines, and tulip-trees occur.

The southern warm temperate zone includes portions of New Zealand and Australia, and in South America the Pampas of the Rio de la Platte, where tree-like grasses abound.

321. The Cold Temperate Zone, or the Zone of Deciduous Trees, or those which drop their leaves in autumn, extends in the northern hemisphere, from the isotherm of 55° Fahr. to 41° Fahr. *Forests of deciduous trees are the main characteristics of this zone;* oaks, birches, beeches, chestnuts, walnuts, maples, elms, larches, alders, and sycamores, are among the most common of the deciduous trees. Mosses and lichens frequently cover the trunks of the trees, and a rich and varied undergrowth occurs; the holly, clematis, wild rose, honeysuckle, and rhododendron, are examples.

Extensive meadows, covered with grasses, are found in this zone.

The deciduous character of the trees, and the almost total absence of evergreens, produce a marked contrast between winter and summer. During winter, the foliage almost entirely disappears, and snow covers the ground for long periods.

This zone is essentially one of extensive forests. In connection with the warm temperate zone of the northern hemisphere, it has always contained the most highly civilized races of men, and is especially rich in the number and luxuriance of its food-plants.

322. The Sub-Arctic Zone, or the Zone of the Cone-Bearing Trees, extends in the northern hemisphere, from the isotherm of 41° Fahr. to regions where the mean annual temperature for the month

Fig. 106. Pine-Trees.

of September is 36.5° Fahr. *In this zone, both forests and grassy meadows abound. The forests are especially characterized by cone-bearing trees, with evergreen, shining, needle-shaped leaves, such* *as the pine, spruce, hemlock, cedar, and fir.* In the northern portions of the zone, beeches and alders are found, and willows, when the soil is moist. The meadows are covered with grasses and flowers, and afford abundant pasturage.

The northern limit of trees is marked on the map of the plant regions.

323. The Polar Zone, or the Zone of Alpine Shrubs, Mosses, Lichens, and Saxifrages, extends from the limits of the sub-arctic zone to the pole. *In this zone, no trees occur except those of a stunted growth.* Alpine shrubs, or those of tortuous, compact growth, such as the Alpine rhododendra, the dwarf birch, willow, and alder, occur. Sedges and grasses are found. The pastures of the preceding zones are absent; in their place we find extended areas covered with lichens.

The northern plains of Siberia are covered with extensive marshes, called *Tundras*, where the ground, during most of the year, is frozen to great depths. The short summers only suffice to thaw the surface, when a few mosses and lichens appear.

Near the extreme northern limits of the North Polar zone, from the limit of the isotherm of 41° Fahr. for the month of July, such plants only are found as can thrive during the brief Arctic summer of from four to six weeks. Shrubs are entirely absent; lichens and mosses occur, together with stunted Alpine herbs. In Spitzbergen, lichens and mosses are found, the former being especially numerous.

324. The Vertical Distribution of Vegetation.—It is difficult to make a good systematic arrangement of *vegetation into vertical zones,* since the *temperature and moisture,* on which such an arrangement must be based, are subject to very considerable variations. Thus, the position of the mountain-ranges as regards the prevalent wind, the direction of the mountain slopes, and the extent of the elevated plateaus, all exert such a powerful influence on the mean annual temperature and the rainfall, that even in the same range, opposite slopes, or even different parts of the same slope, afford very marked climatic contrasts. In ranges that are widely separated, the differences are still greater. The following chart exhibits the characteristic flora in tropical America, Africa, Europe, and Asia, at similar elevations.

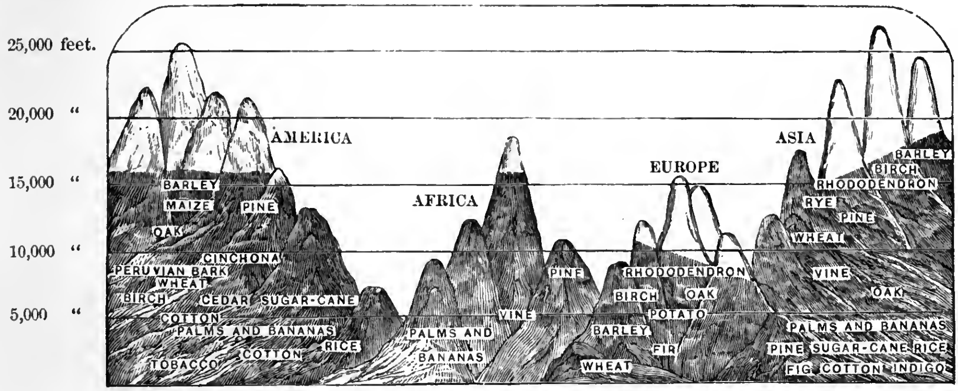


Fig. 107. Vertical Distribution of Vegetation. (After BLACK.)

(1.) Between the level of the sea and 5000 feet, the vegetation is, in general, the same as in the *tropical and sub-tropical zones.* Palms, bananas, and tree-ferns occur in the lower parts, and barley, potatoes, sugar-cane, rice, cotton, etc., as marked on the chart.

(2.) Between 5000 and 10,000 feet, the vegetation is, in general, the same as in warm temperate zones. In America, the birch and cedar occur in the lower portions of the region, and Peruvian bark and the cinchona trees, so useful in medicine, in the upper portions. In Africa and Europe, the pine, birch, and oak occur; and in Asia, the oak; here also the vine is cultivated.

(3.) Between 10,000 and 15,000 feet, the vegetation, in general, is that of the *cold temperate zones.* Deciduous trees occur; rye, wheat, barley, and oats are cultivated.

(4.) Between 15,000 and 20,000 feet, the flora corresponds, in general, to that of the *polar and arctic zones.* A few rhododendrons and birches occur on the warmer Asiatic slopes, and occasionally crops of barley are cultivated. The greater part of this zone is covered by eternal snow, as is the case with all greater elevations.

In the descriptions here given, it will be noticed that the correspondence of the vertical and horizontal zones is but of a very general character. The names of the plants on the chart mark the limits at which they will grow.

325. Plant Regions.—In some localities, a few plants occur over extended areas, in such vast numbers as to give a characteristic appearance to the country they cover. A brief mention will be made of such regions, especially as they illustrate the influence of the presence or absence of moisture on the vegetation.

326. Forests occur wherever the moisture is abundantly and regularly distributed throughout the year. As a rule, forests are limited to those portions of the world where the rain falls at all times of the year, or is abundant during the season the tree is growing, as in the zones of the variable winds. Forests may also occur in portions of the tropics where moisture is abundant.

The forests of the cold temperate zones are *deciduous;* those of the other zones, *evergreen.*

327. Steppes.—When the moisture is not well distributed throughout the year, but the rainfall is periodical, and long droughts occur in the intervals between the rainy seasons, the forests are replaced by areas called steppes, which, during the wet seasons, are covered with grasses, shrubs, or herbs; but during the dry seasons are almost destitute of vegetation. Steppes are found in the Llanos and Pampas in South America, in the Great Plains of North America, in the grassy steppes of Australia, Russia, and Asia, in the German heaths, and in the African savannas.

328. Meadows and Prairies.—These, like the preceding, are covered with tall grasses, but the vegetation is more permanent, the droughts being only occasional. They are found, therefore, in the temperate zones, in the regions of constant rains. An extended prairie region is found in the valley of the Mississippi, on both sides of the stream.

Fig. 108. Desert Scene.

329. Deserts are regions characterized by an almost entire absence of vegetation; they are found mainly in the zones of the trade winds, and are to be ascribed entirely to the absence of moisture. Their bare surfaces are subject to great and sudden changes of temperature, being, as a rule, excessively warm during the day, and often quite cool at night. These changes are due to the readiness with which a bare surface receives and parts with heat.

CHAPTER II.

Cultivated Plants.

330. Plants appear to have been originally confined, by conditions of soil or climate, to certain localities. In many instances, however, plants furnishing materials for food, clothing, or other staples for the human family, have been transplanted and widely diffused by man. In most of these cases, their successful cultivation is limited to regions where suitable climate and soil existed either naturally, or have been artificially produced.

331. Distribution of the Cereals.—The cereals include barley, rye, oats, wheat, maize or Indian corn, and buckwheat; together with the potato, they form the more important food-plants of the temperate zones.

Barley, thought to be a native of Tartary and Sicily, can be grown farther north than any other grain; in Lapland, as far as 70° N. lat.

Rye is found as far north as lat. 67° N. in Norway. It is the most common grain in Russia, Germany, and in portions of France.

Oats is probably a native of the Caucasus; its northern limit in Norway is about 65° N. lat.

Fig. 109. Maize, or Indian Corn.

Wheat is probably a native of Tartary. It is the most important of the cereals, and has a wide vertical and horizontal distribution. Its northern limit, in Norway, is 64° N. lat.

Maize, or Indian Corn, a native of America, is extensively cultivated from the southern part of Chili to high latitudes in North America. Its northern European limit is perhaps near the isotherm of 65° Fahr.

Buckwheat, probably a native of the colder portions of the Chinese Empire, is extensively cultivated in Siberia, on the plateaus of Central Asia, and generally in the cool temperate regions of the rest of the world. Buckwheat is especially valuable on account of the ability it possesses of thriving in sandy or moory soils, where other similar food-plants will not succeed.

Potatoes.—The native country of the potato appears to have been either Chili or Peru. Though cultivated in both the tropical and temperate regions, it is to be regarded as a food-plant of the temperate zones. It possesses a very remarkable range, being cultivated from the extremity of Africa to Lapland: the requisite cold in the tropical regions being found on mountain-slopes.

332. The Food-Plants of the Tropical Regions, are *rice, dates, cocoa-nuts, bananas and plantains, cassava, bread-fruit, sago, yams, etc.*

Rice is cultivated in tropical Africa, Egypt, Nubia, Persia, China, the Americas, and the West Indies. It requires considerable heat and an abundance of moisture. Rice forms the main food of a large portion of the world.

Dates form an important article of food in North Africa, both for man and beast. Dates are obtained from the date-palm, a native of a strip of land on the southern slopes of the Atlas Mountains, where the tree occurs so plentifully as to give to the country the name of *Beled-el-Jerid*, or the Land of Dates. Different varieties of the date are found in the Saharan oases, and in other parts of the world.

Cocoa-nuts are the product of the cocoa-palm, which is valuable for its food, timber, foliage, and fibres. The cocoa-palm is a native of Southern Asia, but is cultivated throughout the tropical regions of Ceylon, Sumatra, Java, and the islands of Polynesia.

Bananas and Plantains are thought to be natives of Southern Asia. They are extensively cultivated throughout the tropical zones, both north and south of the equator. Since their fruit is very nutritious, and the yield of a given area great, they form an exceedingly important staple of food.

Fig. 110. Banana.

Cassava is obtained from the manioc, a shrub with a fleshy root, several feet long, and nearly as thick as a man's arm. Tapioca is one of the varieties of cassava. Some species of the manioc are poisonous, when raw, but become edible when cooked. The manioc is a native of Brazil, but is abundantly cultivated in Western Africa, in Congo and in Guinea.

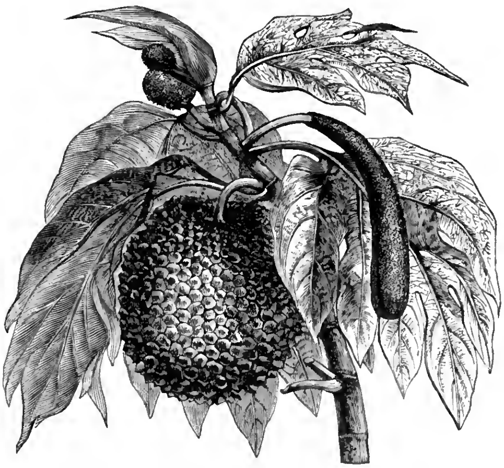


Fig. 111. Bread-Fruit.

Bread-Fruit is the pulpy fruit of a tree which grows only in the tropics. The fruit, when baked, resembles potato bread in taste. The tree yields fruit during most of the year, and is said to be a native of the South Sea Islands, though it is now quite common in the Friendly and Society groups, and in many of the neighboring islands.

Sago is a starchy substance, obtained from the pith of several species of palm trees, which grow in the Moluccas. A single tree is said to yield from 600 to 800 pounds of sago.

Yams are the large tubers of a number of plants, resembling potatoes. They are cultivated in Africa, in South America, and in Cuba.

333.. Sugar-Cane is probably a native of India, but is now extensively cultivated throughout the tropical and warm temperate zones of both hemispheres, in the West Indies and Southern United States, Guinea and Brazil, Mauritius and Bourbon, Bengal, Siam, China, Java, and the neighboring islands.

Fig. 112. Sugar-Cane.

334. Fruits of the Tropical and Warm Temperate Zones.—Besides those already enumerated, we find the following: *oranges, lemons, limes, citrons, pine-apples, mangoes, figs;* and in the cooler portions *cherries, peaches, apricots,* and *pomegranates.*

335. Distribution of Plants yielding Beverages.—The principal plants yielding beverages by infusion are *tea, coffee,* and *cocoa.*

Tea consists of the dried leaves of a number of evergreen shrubs, natives of China or thereabouts. Tea is cultivated in China and India, from the equator as far north as lat. 45°. It appears to thrive best between 25° and 33° N. lat. It is extensively cultivated in Malacca, Java, and in various portions of the English possessions in India. Tea was introduced into Europe by the Dutch, in 1610.

Coffee is the berry of a tree found native in Abyssinia. The tree attains a height of from 15 to 20 feet, but when cultivated, it is generally kept lower by cutting. The tree has shining

Fig. 113. Tea-Plant.

green leaves, and bears beautiful white flowers, which are followed by reddish-brown berries, each of which contains two grains of coffee. The coffee-tree is cultivated extensively in Arabia, Java, the Philippines, Ceylon, Brazil, and in the West Indies.

Fig. 114. Coffee.

Cocoa.—The cocoa-tree is cultivated in Central America, Guiana, Chili, India, Japan, and in several islands in the Indian Ocean. The tree attains a height of about 20 feet. *Chocolate* is prepared from the seed of the cocoa-tree.

336. Spices, such as *pepper, cloves, nutmegs, and cinnamon,* are cultivated mainly within the tropics. *Vanilla,* used in flavoring, is also limited to this region.

Pepper.—*The black pepper* of commerce is obtained from the dried seed of a climbing shrub, which grows wild on the western coasts of Hindostan. *Red, or Cayenne pepper,* is grown in Guiana and the East.

Cloves are the dried flower-buds of an evergreen tree, thirty or forty feet high, which grows in the Moluccas. The cultivation of the tree is confined mainly to the little island of Amboyna.

Nutmegs.—The tree from which nutmegs are obtained is found mainly on the Banda Islands, south of Ceram. The nutmeg is covered by several layers of vegetable matter, one of which is the *mace* of commerce.

Cinnamon is the inner bark of a tree, which is cultivated mainly on the island of Ceylon.

Vanilla is obtained from the dried, fragrant pods of a plant grown mainly in Mexico, Central America, and Brazil.

337. The Principal Narcotics used in different countries are *opium,* prepared from a species of poppy; the *betel-plant,* a native of Hindostan: the leaves of the betel-plant are chewed, together with the areca-nut; *hasheesh,* a narcotic used in India; and *tobacco,* the dried leaves of a plant grown extensively in Mexico, Cuba, Brazil, and in the United States.

338. Plants Valuable as giving Materials for Clothing, are *cotton, hemp, and flax.*

Cotton, a native of India, is now grown extensively in East India, Persia, on the eastern shores of the Mediterranean, in various parts of Europe, and in North and South America.

Hemp and Flax are cultivated in the temperate regions of Russia, and throughout Great Britain and the United States.

The plants producing *medicines,* and products employed in the arts or manufactures, are:

The Cinchona-Tree, found on the upper slopes of the tropical Andes. *Quinine* is obtained from the bark of the tree.

Gum Arabic, obtained from the East Indies, Egypt, and Africa.

Indigo, a blue dye, obtained from the indigo-bearing plants.

Brazil-Wood, Nicaragua-Wood, and Log-Wood, yield reddish dyes.

Quercitron and Black Oak, yield a yellow dye.

Turpentine and Rosin, are products of the pine tree.

Caoutchouc, or India-rubber, is the juice of several tropical plants.

Olive Oil is derived from the olive-tree; cultivated on the borders of the Mediterranean.

Cocoa-nut, Palm, Flaxseed and Cotton-Seed Oils, are obtained respectively from the cocoa-nut, palm-tree, and the seeds of flax and cotton.

SYLLABUS.

All life consists of groupings of cells or spherical masses, consisting of a transparent jelly-like substance called protoplasm.

All life originates in a germ cell produced through the agency of pre-existing life.

Protoplasm forms an essential part of all plants and animals. Both plants and animals consume protoplasm during their growth. Plants, alone, produce protoplasm. Animals are dependent on plants for their existence.

Plants require for their vigorous growth certain conditions of light, heat, moisture, and soil; of these, heat and moisture are the most important.

Plant geography treats of the distribution of plants. It differs essentially from botany, which treats of the peculiarities in the structure of plants.

The plants of any section of country, taken collectively, are called its flora.

The differences in the distribution of heat and moisture, produce corresponding differences in the distribution of vegetation. The distribution of heat and moisture, therefore, forms the true basis for the distribution of plant life.

If a soil be wanting in any section of country, but the proper conditions of light, heat, and moisture be present, the simpler vegetable forms will appear, and gradually prepare a soil fitted for the higher kinds of vegetation.

The variety and luxuriance of vegetation decrease as we pass from the base to the summit of a mountain, or from the equator to the poles; this decrease is caused by a corresponding decrease in the amount of heat and moisture.

According to the horizontal distribution of plants, the surface of the earth is divided into the following zones: the tropical, sub-tropical, warm temperate, cold temperate, sub-arctic, and polar.

The tropical zone is characterized by the prevalence of palms, bananas, spices, and aromatic plants.

The sub-tropical zones are characterized by the prevalence of laurels, myrtles, and magnolias.

The tropical and sub-tropical zones, especially the former, are particularly characterized by an especial luxuriance of their vegetation.

The warm temperate zones are characterized by forests of evergreen trees.

The cold temperate zones are characterized by forests of deciduous trees.

Deciduous trees are those which cast their leaves in autumn. Oaks, birches, beeches, chestnuts, walnuts, maples, elms, larches, alders, and sycamores are among the most common of the deciduous trees.

Extensive grass-covered meadows are found in the cold temperate plant zones.

The sub-arctic zone is characterized by cone-bearing trees. The polar zone, by Alpine shrubs and mosses.

Forests require, for their luxuriant growth, an abundance of moisture, evenly distributed throughout the year, or during the time the trees are growing.

Steppes are regions covered with a scanty vegetation; they are produced either by insufficient moisture, or its irregular distribution throughout the year.

The principal cereals are barley, rye, oats, wheat, maize, corn, and buckwheat.

The principal food-plants of the tropical regions are rice, dates, cocoa-nuts, bananas, plantains, cassava, sago, yams, and bread-fruit.

Some of the most important plants cultivated for the beverages they yield, are tea, coffee, and cocoa.

The principal spices are pepper, cloves, nutmegs, and cinnamon. The principal narcotics are opium, betel, hasheesh, and tobacco.

Cotton, hemp, and flax are valuable as furnishing materials for clothing.

The cinchona-tree yields quinine.

REVIEW QUESTIONS.

What is protoplasm? Of what does all life consist?

In what respect are animals dependent upon plants for their existence?

Define plant geography. In what respect does it differ from botany? Name the conditions requisite for plant growth.

How do these conditions compare with each other in importance? Describe the formation of soil.

Why is soil of comparatively less importance to the existence of vegetation than heat or moisture?

What do you understand by the horizontal distribution of vegetation? By the vertical distribution?

What is the main cause of the difference in the flora of different parts of the world?

Why should the isothermal lines generally form the boundaries of the plant zones?

Name the horizontal zones of vegetation.

State the boundaries of each of these zones.

What is the characteristic flora of the tropical zone?

Why should the vegetation of the tropics be so much more luxuriant than that of the rest of the world?

Why should the same change be noticed in the vegetation of a high tropical mountain, in passing from its base to its summit, as in passing along the earth's surface from the equator to the poles?

Describe the vertical vegetable zones. To what horizontal zone does each of these correspond?

Name the conditions requisite for the luxuriant growth of forests. How do the forests of the cold temperate zones differ from those of other zones?

By what climatic conditions are steppes produced?

What conditions are requisite for the production of meadows and prairies? How are deserts produced?

Name some of the more important cereals.

Which of the cereals form the principal food-plants of the temperate zones? Which of the cereals has the farthest northern range? Which is the most important?

Name the principal food-plants of the tropical regions.

What is the principal region for the cultivation of dates? Name the principal regions in the world noted for the successful cultivation of the sugar-cane.

Name the fruits of the tropical and warm temperate zones.

In what portions of the world is coffee successfully cultivated? Where is tea cultivated?

From what tree is chocolate obtained?

From what plant is black pepper obtained? Where is the plant cultivated?

From what are cloves obtained? Where is the tree cultivated? Where are nutmegs grown? What is mace?

In what part of the world is cinnamon cultivated?

Name the principal narcotics used in different parts of the world.

Name the plants which furnish valuable materials for clothing.

From what tree is quinine obtained?

Name some of the principal vegetable dyes.

MAP QUESTIONS.

Trace on the map showing the distribution of vegetation, the parts of the world included in the tropical zone.

Name the plants of the tropical zone which are characteristic of South America. Name those of Africa. Of India and Australia.

Describe the principal region of the cocoa-nut palm, bread-fruit, sago, and yam in the eastern continent.

Describe from the map the limits of the sub-tropical zones. Describe the characteristic flora of those portions of each of the continents which lie within these zones.

Describe the limits of the warm temperate zones. Of the cold temperate zones. Of the sub-arctic zone. Of the polar zone.

Trace on the map the northern limit of trees. Trace the southern limit of trees.

Name some of the trees of the warm temperate zones. Of the cold temperate zones. Of the sub-arctic zones.

In what parts of the world are pasture-lands found?

Name the characteristic plants of the regions which lie north of the arctic circle.

Trace on the map showing the vertical distribution of vegetation, the characteristic plants found in Africa, between the level of the sea and 5000 feet. In Europe. In Asia. In America.

SECTION II.

ANIMAL LIFE.

CHAPTER I.

Zoological Geography.

339. Zoological Geography treats of the distribution of animal life. The animals found in any region of country are called its *fauna.* Like plants, animals appear to have been originally created in certain localities, from which they have spread, more or less, over adjoining areas.

Though able to move about freely from place to place, animals are, nevertheless, restricted, by conditions of *food and climate,* to well-defined areas. Animals derive their sustenance, either directly or indirectly, from plants.

340. Distribution of Animal Life.—The distribution of *heat, moisture, and vegetation* forms the true basis for the distribution of animal life.

We distinguish a *horizontal and a vertical distribution of animal life.*

As a rule, the luxuriance and diversity of terrestrial animal life decrease as we pass from the equator to the poles. A similar decrease is noticed in passing from the coasts of the continents toward the interior. Within the tropics, where the abundant heat and moisture produce a vigorous vegetation, all forms of terrestrial animal life, save man, attain the greatest development in size, intelligence, and activity. As we proceed toward the poles, the species are less developed, although, in the temperate regions, large and vigorous animals are still numerous. In the polar zones, the reindeer and white bear are the only representatives of the larger land animals.

In *marine animal life,* the law of distribution is reversed, both the number and size of the species increasing from the equator toward the poles. This is probably due to the more equable temperature of the ocean in high latitudes.

341. The Vertical Distribution of Life.—In

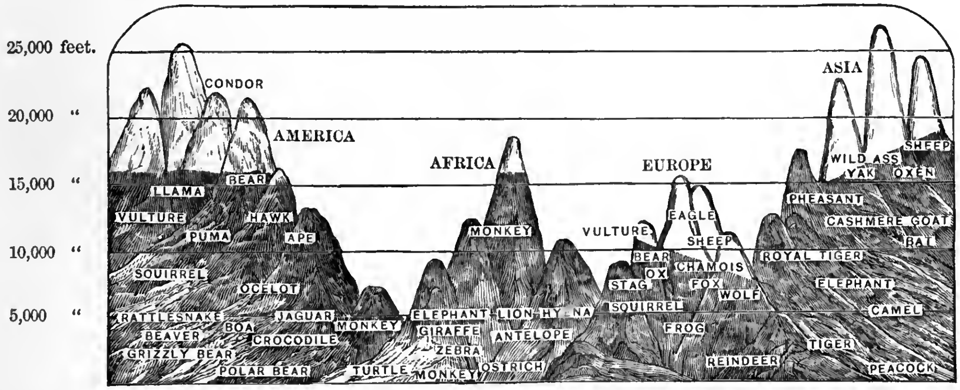


Fig. 115. Vertical Distribution of Animal Life. (After BLACK.)

passing from the base to the summit of a tropical mountain, the same change is noticed in the species of animals, as in passing along the surface of the earth from the equator to the poles.

In the above chart, the names of the animals are placed at the greatest elevation at which they are found. The power of locomotion possessed by animals renders it extremely difficult to arrange the fauna in zones according to the altitude. In general, however, the animals found on the slopes of tropical mountains, at elevations included between the sea-level and from 5000 to 7000 feet, correspond to those inhabiting the tropical zone; between 5000 or 7000 feet and 15,000 feet, to those of the temperate zones. The condor is found in the high Andes, far above the snow line.

The fauna of high mountain-ranges are often sharply marked. A particular species, at a given elevation on one range, is frequently entirely wanting on a neighboring disconnected range, even when the same conditions of heat, moisture, and vegetation exist. The temperature of the intervening lower country, through which the animals would have to pass in order to reach the adjoining slopes, forms an impenetrable barrier.

342. Natural Boundaries of Zones of Animal Life.—Large bodies of water, deserts, or mountain-ranges, mark the boundaries of regions of animals as well as of plants; but the influence of temperature is so important, that even when these natural barriers are wanting, the *horizontal range of animals* is sharply marked by the isothermal lines.

In North America, there are well-marked zones of animals, which extend from east to west across the continent. Here, although no natural barriers exist to limit the wider range of the animals, yet they seem unable to permanently pass the limits of the isotherms, which mark the climatic conditions necessary to their vigorous growth. This inability doubtless arises from the distribution of the flora, on which, directly or indirectly, they are dependent for their food.

343. Acclimation.—The power of becoming *acclimated,* or being able to live in a climate differing from that in which they were first created, appears to be possessed by animals, as a class, to an exceedingly limited extent.

Man, and his faithful friend, the dog, form an exception to most other animals in this respect. They are able to endure both the severe heat of the tropics, and the rigor of the Arctic regions. The reindeer thrives amid the snows of Lapland or Greenland, but perishes from the heat of St. Petersburg. Monkeys are indigenous to the tropics, but die with consumption, even in the comparatively mild climate of the north temperate zones.

344. Horizontal Distribution of Animal Life.—The vast number of species of animals, the peculiar laws of their growth, and their power of adaptation to change of circumstances, render their accurate distribution into zones or regions a task far beyond the scope of an elementary book. It will be sufficient for our purpose to divide the *fauna of the earth* into those found, in general, in the three mathematical climatic zones: *the Torrid, the Temperate, and the Polar.* The accurate limits of these zones would be found in the isotherms, but in a general description, little difference would be noticed. On the map, the actual limits of some of the more important animals are given. These limits, it will be noticed, in most cases follow the general direction of the isotherms.

345. Characteristic Fauna.—A careful study of the map of the distribution of animal life, will show that each continent possesses a fauna peculiar to itself. This arises, generally, from some clearly traceable peculiarity in the distribution of the heat and moisture, or in the nature of the vegetation. Some of these peculiarities will be discussed in a brief review of the characteristic fauna of each of the continents. The following are the characteristic *tropical, temperate, and arctic fauna.*

346. Tropical Fauna.—The abundance of heat, moisture, and vegetation of the torrid zone causes its fauna to excel all the others in the number and diversity of terrestrial species, as well as in their size, strength, and sagacity.

The following animals are found mainly within the regions of the earth included between the Tropics of Cancer and Capricorn.

Mammalia are represented as follows:

Monkeys, by the man-like *orang-outang,* the *chimpanzee, gorilla, baboon,* and other species.

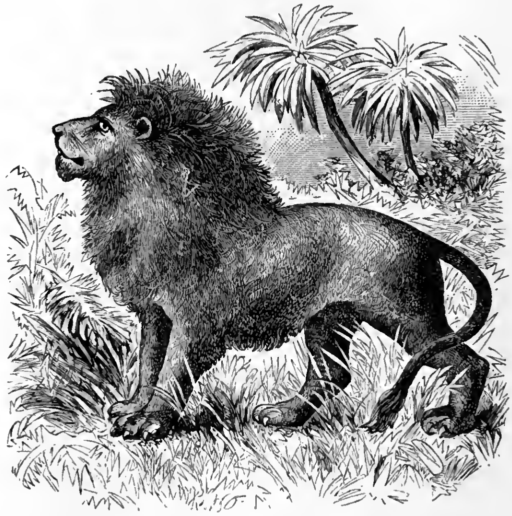


Fig. 116. Lion.

Carnivora, or *flesh-eating mammals,* by the *lion, tiger, panther,* and *puma.*

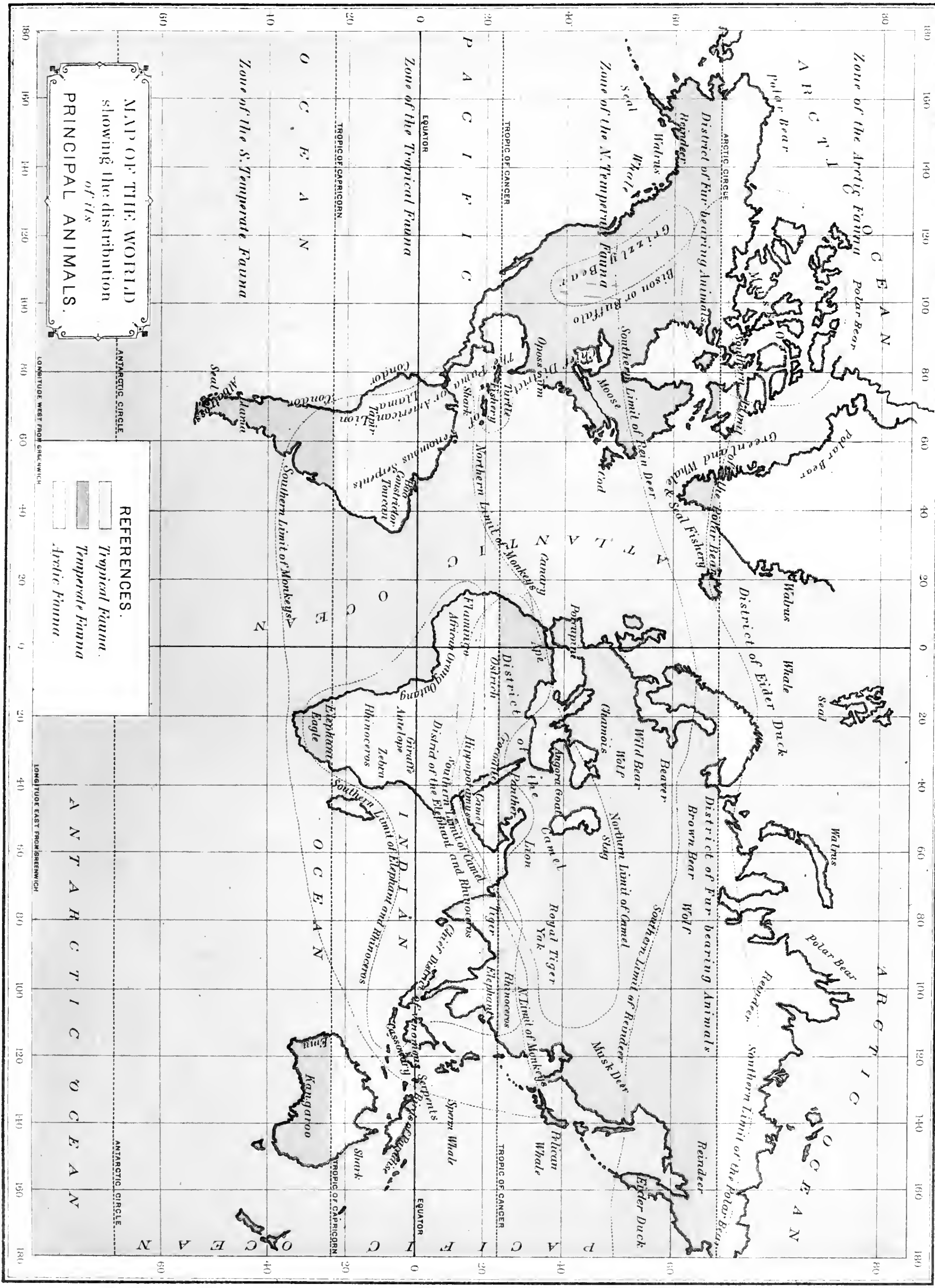
Herbivora, or *plant-eating mammals,* by the *elephant, rhinoceros, tapir, and hippopotamus,* the horse-like *zebra and quagga,* the *giraffe or camelopard,* and the *camel.*

Cetacea, or *whales,* by the *sperm whale,* found only in tropical or temperate waters.

Cheiroptera, or *bats,* by a number of species.

Marsupials, by the *kangaroo* of Australia.

Birds are represented, in tropical regions, by


MAP OF THE WORLD
showing the distribution
of its
PRINCIPAL ANIMALS.
REFERENCES.
Tropical Fauna.
Temperate Fauna
Arctic Fauna.
ARCTIC OCEAN
PACIFIC OCEAN
ATLANTIC OCEAN
INDIAN OCEAN
ANTARCTIC OCEAN
Zone of the Arctic Fauna
Zone of the N. Temperate Fauna
Zone of the Tropical Fauna
Zone of the S. Temperate Fauna
ARCTIC CIRCLE
TROPIC OF CANCER
EQUATOR
TROPIC OF CAPRICORN
ANTARCTIC CIRCLE
LONGITUDE WEST FROM GREENWICH
LONGITUDE EAST FROM GREENWICH
District of Fur bearing Animals
Grizzly Bear
Bison or Buffalo
Southern Limit of Rein Deer
Greenland Whale & Seal Fishery
Southern Limit of the Polar Bear
Northern Limit of Monkeys
Southern Limit of Monkeys
District of Eider Duck
District of the Panther
African Orang Outang
District of the Elephant
Southern Limit of Elephant and Rhinoceros
Northern Limit of Camel
Southern Limit of Reindeer
N. Limit of Monkeys
Polar Bear
Walrus
Whale
Seal
Reindeer
Moose
Cod
Opossum
Condor
Llama
Albatross
Turtle
Shark
Toucan
Canary
Porcupine
Ape
Ostrich
Flamingo
Giraffe
Antelope
Zebra
Rhinoceros
Elephant
Eagle
Hippopotamus
Crocodile
Camel
Lion
Tiger
Angora Goat
Chamois
Wild Boar
Wolf
Beaver
Brown Bear
Stag
Royal Tiger
Yak
Musk Deer
Pelican
Sperm Whale
Kangaroo
Emu
Cassowary
Birds of Paradise
Elder Duck

species noted for their great size and strength, or for the brilliant colors of their plumage. Among those noted for their size may be mentioned the *condor, ostrich, eagle, ibis, flamingo,* and *cassowary;* among those especially noted for their plumage, the *birds of paradise, peacock,* and *parrots,* and the *humming-birds* of South America, which latter, though in less brilliantly-colored plumage, extend nearly to the extreme limits of the north and south temperate zones.

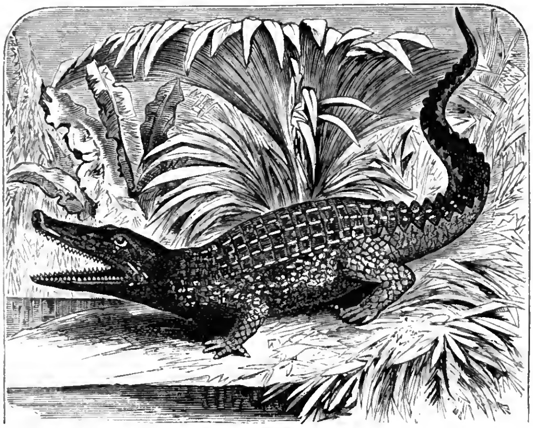


Fig. 117. Alligator.

Reptiles are represented by the *crocodile, alligator, iguana, gigantic lizards,* and *turtles;* among serpents, the enormous *boa-constrictor,* and numbers of hooded and other venomous serpents.

The Fish of tropical waters, though large and brightly colored, are not so well adapted for food as the more sombre varieties of the temperate or colder waters.

347. Temperate Fauna.—The following animals are found mainly between the tropics and polar circles. Though fewer of the higher species of animals are found in the temperate zone than in the torrid zone, yet many of the fauna are of large size, and among them are found animals most useful to man.

The physical tropical zone, as will be seen from an inspection of the map of plant life, actually extends, in the eastern continent, far into the mathematical north temperate zone, and in these portions the corresponding tropical species occur. Thus, in Northern Africa and Southern Asia, are found the *ape, tiger, lion, panther, camel,* and *rhinoceros.*

Mammalia are represented as follows:

Flesh-eating mammals, by the *lynx, hyena, wolf, jackal, dog, fox, raccoon, bear, seal,* and *walrus.*

Plant-eating mammals, by the *wild boar* and *hog,* the *horse, ass, ox, sheep, goat,* and *chamois,* many of which have been domesticated, as the *moose, elk, reindeer, stag, antelope, buffalo, camel, llama,* and numerous others.

Cetacea, or *whales,* by the *sperm* and *white whales.*

Rodentia, or *gnawing mammals,* by the *beavers, squirrels, rats,* and *porcupines.*

Marsupials, by the *kangaroo* of Australia.

The birds of the temperate zones are represented by the *condor, vulture, hawk, eagle, owl,*

Fig. 118. Eagles.

and *parrot* (near the southern limit of the zone). The *turkey, pheasant,* and our common domestic fowls also are natives of this zone. Here occur numerous birds which are noted for the sweetness of their song, as the *wren, thrush, robin, nightingale,* and *lark;* the *pelican, albatross,* and the *cassowary* are found in this zone.

Reptiles are represented by the *alligator, crocodile,* and *lizard,* and the *rattlesnake, copperhead,* and various other serpents, both poisonous and harmless.

348. Arctic Fauna.—The following animals are found mainly between the polar circles and the poles. The south arctic fauna is but little known; the following description, therefore, refers mainly to the northern hemisphere:

In the arctic regions of the world, the large land animals are, with a few exceptions, replaced by numerous smaller furry species. Throughout the northern portions of the north temperate zone, and the southern portions of the arctic, *fur-bearing animals* are especially numerous and valuable.

The *white polar bear*, the *reindeer, moose*, and the *musk-ox*, are among the largest of the land species; but in warmer regions of the oceans, numerous species exist, among which are individuals as large as any in the animal world.

The *Greenland whale*, which sometimes attains the length of seventy feet, and is covered with blubber to a thickness of two or three feet, is found only in this zone. A similar, though smaller, species occurs in the southern waters. The *seal* and *walrus* are also found in this zone.

Fig. 119. Seals and Walrus.

Besides the larger animals, numerous smaller species, such as minute *zoöphytes, mollusks*, and *crustaceans*, which form the food of the whale, and which, in some places, exist in immense numbers, inhabit the waters. Among birds, innumerable *water-fowl* occur.

CHAPTER II.

Characteristic Fauna of the Continents.

349. Characteristic Fauna of the Continents.—Each of the continents is characterized by some peculiarity in its fauna. This peculiarity arises either from the nature of the vegetation, or the distribution of the heat and moisture, and affords an excellent example of the intimate connection between the physical features of a country, and its flora and fauna. Only the general characteristics of the fauna will be given.

For the particular animals inhabiting each continent, the student is referred to the map of the distribution of animal life.

350. North American Fauna.—The chief characteristic of the North American fauna is found in the *preponderance of plant-eating mammals.* This feature is due to the abundance of pasture-lands, and their luxuriant vegetation. From its extensive lake and river systems, North America is peculiarly fitted to sustain aquatic life; hence, its numerous *water-fowl* and *beaver.*

351. *Fur-bearing* animals are particularly numerous and valuable. Three natural districts of fur-bearing animals exist: the *forest region*, the *prairie region*, and the *barren regions of the north*, each of which is characterized by a peculiar fauna.

Forest Region.—Here, among carnivora, are found the *black bear, marten, ermine, mink, otter*, the *silver fox*, the *black fox*, and the *lynx;* among the rodentia, the *beaver* and *musk-rat;* and among the ruminants, the *moose* and *reindeer.* The wolverine and wolf are found both in the forest region and the barren grounds.

Barren Grounds.—The *brown* and *polar bears*, the *polar fox*, and the *polar hare* are characteristic.

Prairie Region.—The *grizzly bear*, the most formidable animal of the continent; the *prairie wolf*, and the *gray fox* are also found here.

The *puma*, or the *American lion*, which is found also over the greater part of South America, is the most powerful representative of the lion and tiger tribe of the East.

352. South American Fauna.—The chief characteristics of the South American fauna arise from the extreme luxuriance of its vegetation, due to the abundance of its moisture. In vast districts, as the Selvas of the Amazon, the vegetable world usurps the ground nearly to the exclusion of the higher forms of animal life. The *fauna* is, therefore, as a rule, characterized by its fitness for existing in connection with either an abundance of water or of vegetation.

Insect Life is peculiarly characteristic of the continent. Nowhere else are the species so numerous, so brilliantly colored, or so large. Here are found the largest of the beetles, and the most beautiful of the butterflies.

Reptiles are largely represented. They find, in the tepid, sluggish waters of the huge rivers, conditions most favorable to rapid growth. Here live the *crocodile, gigantic lizards,* and many venomous serpents.

Among Birds, the water species are in the ascendance. Humming-birds, which occur also in North America, are found in great abundance in the southern continent. The *condor* is found on the higher slopes throughout the Andes; the *ostrich, toucan,* and *parrot* are also characteristic.

Among the Mammalia, the *ant-eaters* and *sloths* peculiarly characterize the continent. The *tapir* and *peccary* are the only representatives of the elephant, rhinoceros, and hippopotamus of the Eastern continents. The *llama, puma,* and the *prehensile-tailed monkeys* are also characteristic of the region.

The South American district of *fur-bearing animals* extends through parts of Chili and the Argentine Republic. The *marsh beaver* is the principal animal.

353. Asiatic Fauna.—From the great mass of land within the tropics, the fauna of Asia, besides its numerous *arctic and temperate species,* contains a great variety of tropical forms.

Taken in connection with Northern Africa, Asia is essentially the region of extensive dry plains and arid tracts. The vegetation throughout its temperate climes is greatly inferior to that of America, but its animal life is marked by a much greater variety in the higher forms. Foremost among these are the man-like *monkeys,* the *orang-outang,* the *elephant,* the *royal tiger,* and others. *Fur-bearing animals* are also numerous. Among birds, those with bright, gay-colored plumage abound. Reptiles also are represented, though not to such an extent as in South America.

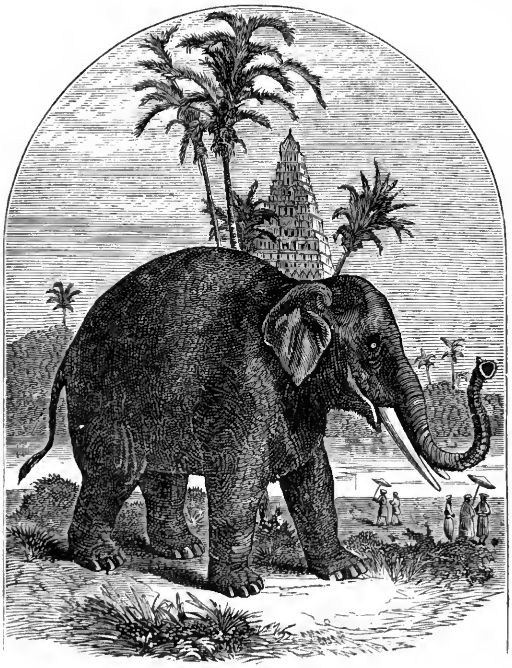


Fig. 120. Elephant.

When we bear in mind that in Asia, the horse, ass, goat, sheep, camel, swine, elephant, buffalo, and ox are found in great numbers, it will be seen that Asia, the home of primitive man, is also peculiarly the home of *domesticated animals;* that is, of the animals which man has trained to labor for him.

The Asiatic district of *fur-bearing animals* includes Siberia, Kamtchatka, and the basin of the Amoor River in Mantchooria. The following animals are characteristic: the *brown bear, badger, weasel, ermine, sable, otter, marten,* and many others. The furs of the sable, black fox, otter, and the ermine, are considered the most valuable.

354. African Fauna.—The peculiarities of the northern portion of the continent have been already pointed out in connection with Asia. It is a fact worthy of notice, that the great deserts of the world, like the Sahara, though nearly destitute of any vegetation, are able to sustain many of the highest species of animals.

Over these tracts are found the lordly *lion,* the *leopard,* and the *panther,* and the numerous animals on which they prey, such as the *antelope,* the *zebra,* the *quagga,* and others. All these possess powers of rapid locomotion, which peculiarly fit them for the arid plains over which they roam.

In the remaining portions of Africa, the luxuriant vegetation is capable of sustaining animals of a larger growth. Here occur the largest of the Mammalia, such as the *elephant, rhinoceros,* and *hippopotamus;* here also is found the *giraffe,* the largest of the ruminantia; man-like *monkeys* are also characteristic.

355. Australian Fauna.—The more nearly perfect isolation of Australia than any of the other continents, together with the peculiar distribution of its heat and moisture, causes its fauna and flora to differ markedly from those of all the other continents.

Australia is essentially *the home of the marsupials.* These are both carnivorous and herbivorous. The *kangaroo* is, perhaps, the most characteristic of the marsupials. Large and powerful animals are entirely absent; in this respect the continent offers a sharp contrast to Africa.

The birds are also of peculiar species, such as the *emu, cassowary, dodo,* and *apterix.*

CHAPTER III.

The Distribution of the Human Race.

356. Ethnography is that department of physical geography which treats of the varieties of the human race, and their distribution.

The range of the distribution of man is much greater than that of the lower animals, which, as we have already seen, with the trifling exception of a few that have been domesticated, are confined to certain limited localities. Man has far greater powers of adapting himself to a change of circumstances, and is found in nearly all the climatic zones, from the equator to the poles, and at all elevations, from the level of the sea to the edge of the snow line.

357. Unity of the Human Race.—Although the different races of men vary greatly in *color, size, stature,* and *intelligence,* still a number of circumstances point to their descent from a single family or species.

(1.) **The Anatomical Structure** is invariably the same in all races.

(2.) **Gradual Modification of Types** presented by the different races. The more marked outward peculiarities, which serve as the basis for classification, pass into each other, by almost insensible gradations, from the highest race to the lowest. This points to a gradual modification of a single, original race by changes in external circumstances, thus producing the present varieties. It would appear that all the varieties of the race have descended from the Caucasians, or whites.

(3.) **Similarity of Earlier Myths and Legends.** Since the earlier myths and legends of nearly all nations resemble each other, it is fair to infer that their remote ancestors originally dwelt together.

(4.) **Close Resemblance of Language of Widely Separated Races.** This may be regarded as the strongest proof of unity.

If we examine the words used in different nations to express the most common ideas, we will find a remarkable similarity between many of them. For example, our word *father* is *pita* in Sanscrit, *pater* in Latin, *pater* in Greek, *vater* in German, and *père* in French. The same similarity is noticeable in the words for *mother, sister, brother, daughter, God,* and many others. The only rational explanation for the resemblance is, that the words were derived from the same parent language, the present differences having been gradually acquired, as the descendants of this earlier people wandered farther and farther from their common home.

An extended comparison made in this way between different languages, has shown the common origin of the languages of Europe and a large part of Asia. It has been conclusively proved that these tongues owe their origin *to one parent nation,* which dwelt, during pre-historic times, in the neighborhood of Mt. Ararat and Mesopotamia.

Other families of languages, such as the Chinese and Semitic, have been studied, but thus far the connection between the different families has not been certainly established.

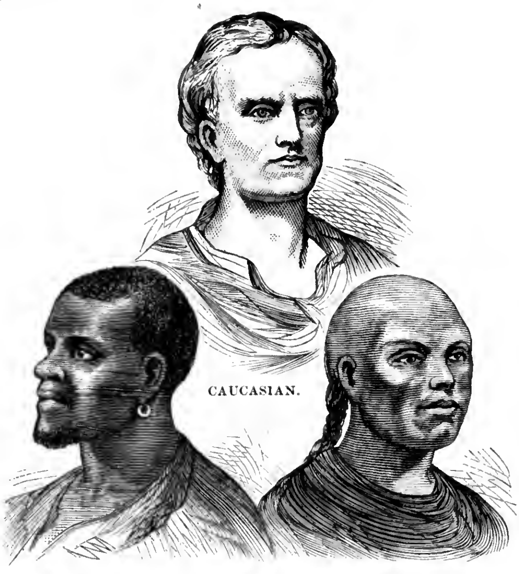
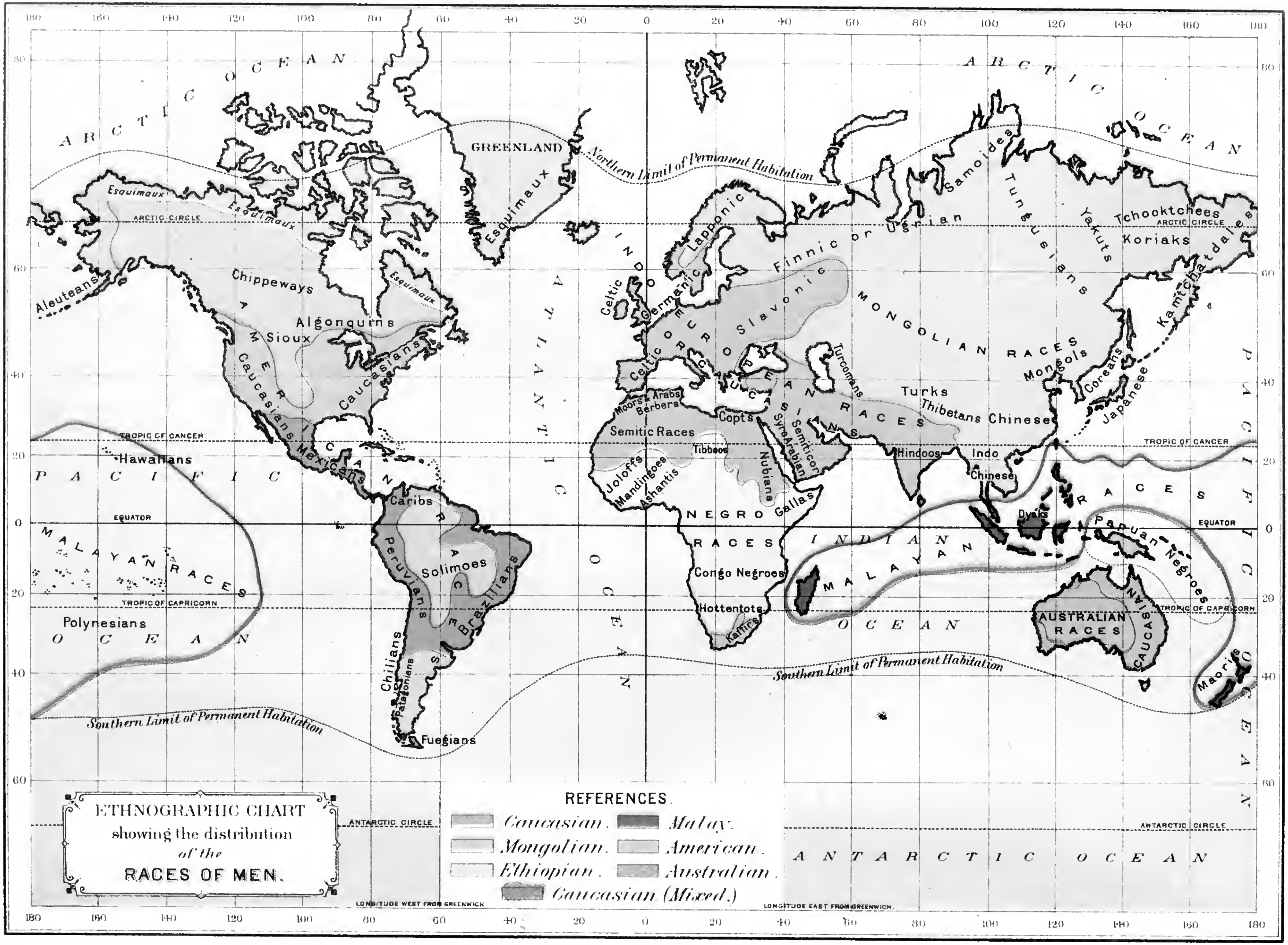


Fig. 121. Primary Races of Men.

358. The Races of Men.—Among the varieties of the human race, three strongly-marked types are found: the *Caucasian,* the *Mongolian,* and the *Negro.* These, which may be regarded as the primary races, are grouped around three geographical centres, which correspond nearly to the centres of the three divisions of the Old World.

The Caucasian type is found in most of Europe and in South-western Asia; the Mongolian type, in those parts of Europe and Asia not occupied by the Caucasian; the Negro type, in Africa. The other parts of the world are peopled mainly by three other races, which, in general, bear close resemblances to the preceding. These are the *Malay,* the *American,* and the *Australian.* They


ETHNOGRAPHIC CHART
showing the distribution
of the
RACES OF MEN.
REFERENCES.
Caucasian.
Malay.
Mongolian.
American.
Ethiopian.
Australian.
Caucasian (Mixed.)
ARCTIC OCEAN
PACIFIC OCEAN
ATLANTIC OCEAN
INDIAN OCEAN
ANTARCTIC OCEAN
Northern Limit of Permanent Habitation
Southern Limit of Permanent Habitation
ARCTIC CIRCLE
TROPIC OF CANCER
EQUATOR
TROPIC OF CAPRICORN
ANTARCTIC CIRCLE
LONGITUDE WEST FROM GREENWICH
LONGITUDE EAST FROM GREENWICH
GREENLAND
Esquimaux
Aleuteans
Chippeways
Algonquins
Sioux
AMERICAN RACES
Caucasians
Mexicans
Caribs
Peruvians
Solimoes
Brazilians
Chilians
Patagonians
Fuegians
Hawaiians
MALAYAN RACES
Polynesians
INDO EUROPEAN
Celtic
Germanic
Lapponic
Finnic or Ugrian
Slavonic
CAUCASIAN RACES
Moors & Arabs
Berbers
Semitic Races
Copts
Syro Arabian
Semitic
Turcomans
Tibboos
Joloffs
Mandingoes
Ashantis
Nubians
Gallas
NEGRO RACES
Congo Negroes
Hottentots
Kaffirs
Samoides
Tungusians
Yakuts
Tchooktchees
Koriaks
Kamtchatdales
MONGOLIAN RACES
Mongols
Coreans
Japanese
Turks
Thibetans
Chinese
Hindoos
Indo Chinese
MALAYAN
Dyaks
Papuan Negroes
AUSTRALIAN RACES
CAUCASIAN
Maoris

are called the secondary races, and appear to be modifications of the Mongolian.

359. Cranial Characteristics.—The primary races are sharply distinguished by the following types of skull:

Caucasian. The skull is nearly oval, and the arch of the cheek-bones moderate.

Mongolian. The skull is nearly round, the occipito-frontal diameter, or the distance from the forehead to the back of the head, is slightly greater than the parietal diameter, or that between the temples.

Negro. The skull is elongated from the back of the head to the forehead; that is, the occipito-frontal diameter greatly exceeds the parietal. The cheek-bones are large and projecting.

360. The Caucasian, or White Race is characterized by a round or oval head; symmetrical features; vertical teeth; round or oval face; arched forehead; fair complexion, and ample beard.

The Caucasian race inhabits South-western Asia (Hindostan, Persia, and Arabia), Northern Africa, and nearly the whole of Europe. The descendants of the race now people large portions of America, Australia, and Southern Africa.

361. Divisions of the Caucasian Race.—The Caucasian race may be divided into three branches: the *Hamitic*, the *Semitic*, and the *Japhetic*.

(1.) *The Hamitic Races* originally inhabited Palestine, the shores of the Arabian Peninsula, and the valley of the Nile. They are now, however, scarcely distinguishable from the other branches of the Caucasian race, with whom they have intermarried.

(2.) *The Semitic, or Syro-Arabian Races*, comprise the modern Syrians, the Jews or Hebrews, the inhabitants of Arabia and Abyssinia, and the greater part of Northern Africa.

Among the ancient peoples belonging to this branch of the Caucasian race, are the Assyrians and Babylonians, the Israelites, Moabites, Ammonites, Edomites, Ishmaelites, and Phœnicians.

(3.) *The Indo-Europeans, or the Aryan Race*, comprise the Japhetic race. They are the most civilized peoples of the world, and include the following nations:

(1.) *Celtic Nations*, including the Irish, Welsh, Scots, and the Bretons of France.

(2.) *Romanic Nations*, comprising the Italians, Spaniards, Portuguese, and the French.

(3.) The ancient Greeks.

(4.) *Germanic Nations*, comprising the Germans, Anglo-Saxons (English), Dutch, Flemish, Danes, Swedes, and the Norwegians.

(5.) *Slavonic Nations*, comprising the Russians, Poles, Croats, and Czechs.

(6.) *Nations of the Iranian Plateau*, comprising the Persians, Belooches, and the Afghans.

(7.) *The Hindoos.*

362. The Mongolian, or Yellow Race.—The chief characteristics of the Mongolian race are: broad head; angular face; high cheek-bones; small, obliquely-set eyes; straight, coarse, black hair; scanty beard, and short stature. The color of the skin varies from pale lemon to brownish yellow.

The Mongolian race includes the inhabitants of all of Asia, except a small part of the Malay Peninsula, and those portions of the continent occupied by the Caucasians. It also includes the Lapps and Finns, inhabiting the northern portions of Europe, the Turks of Europe, and the Magyars of Hungary, In America, the race is represented by the Esquimaux, who inhabit Greenland and the northern borders of the North American continent.

In Central Asia, the race is represented by the Thibetans, Chinese, Indo-Chinese, and others.

In Northern Asia, by the Samoides, inhabiting the shores of the Arctic Ocean, from the Petchora to the Yenisei, and south to the Altai Mountains; the Ugrian, or Finnic races, inhabiting the upper valley of the Obe, and a part of Northern Europe; the Tchooktchees, the Tungusians, and the Yakuts, of North-eastern Asia.

Other branches of the race, are the Coreans, Japanese, Kamtchatdales, Koriaks, and the Mongols.

363. The Negro, or Black Race.—The chief characteristics of this race are: narrow and elongated head; crisp and curly hair; projecting jaws; thick lips; soft and silky skin; color black or dusky; scanty beard, especially on upper lip; broad feet, and projecting heel-bones.

The race inhabits the entire continent of Africa, excepting those parts occupied by the Caucasians.

The following are the most important varieties of the race: the Jaloffs, Mandingoes, and Ashantis, in the western part; the Tibboos, in the north central; the Gallas, in the eastern; the Congo Negroes, in the south central; and the Hottentots and Kaffirs, in the extreme south.

The Negro tribes differ greatly in their civilization: the Gallas, though cruel and vindictive, are a handsome, gifted race; the Hottentots, on the contrary, are among the most debased creatures in existence.

364. The Secondary Races.—The *Malay, or Brown Race;* the *Australian;* and the *American, or Copper-colored Race, are modifications of the Mongolian Race.*

365. The Malay, or Brown Race.—The principal characteristics of this race are the same as those which distinguish the Mongolian; the eyes, however, are horizontal, the face flat, and the hair less coarse and straight. The color of the skin varies from a clear brown to a dark olive. In the Papuans, it is dark brown, and even black.

Fig. 122. Secondary Races of Men.

This race inhabits the southern part of the Malay Peninsula, the island of Madagascar, and the islands of the Indian and Pacific Oceans.

The different peoples included under the Malay race present the most strongly marked contrasts. The Papuans, for example, differ widely in their appearance from the normal Malay. They are, perhaps, allied more closely to the *Australians* than to any others.

366. The Australian Race is to be regarded as a sub-variety of the Papuan branch of the Malays. It inhabits all the continent of Australia not settled by the whites.

The Australian race possesses the following characteristics: the head is large; eyes deep-set; nose broad; hair dark; beard abundant. The color of the skin varies from dark brown to deep black. The Australians are almost wholly destitute of civilization.

367. The American, or Copper-colored Race, though containing many widely differing varieties, yet possesses, in some respects, many common features. Its general resemblance to the Mongolian is evident, but the top of the skull is more rounded, and the sides less angular. This race, though once numerous and powerful, is now rapidly disappearing before the whites.

In Lower California, Mexico, Peru, and Brazil, the old races have become mixed with Spanish and other elements.

The ruins of temples, and once populous cities, are common on the high Andean plateaus. These parts of the earth were inhabited at the time of the discovery of the continent by a people who had made considerable progress in the art of working metals, and who were probably of Asiatic origin.

The plateaus of Central America contain the traces of a still higher, though more ancient civilization, the origin of which is unknown, though some trace it to a Semitic or an Egyptian source.

SYLLABUS.

The animals of any section of country are called its fauna.

Notwithstanding their powers of locomotion, animals are restricted, by conditions of food and climate, to well-defined areas.

Since animals are dependent for their existence upon plants, the heat and moisture of any given section of country form the true basis for the distribution of its fauna.

We distinguish a horizontal and vertical distribution of animal life.

The same change is noticed, in the species of animals, in passing from the base to the summit of high tropical mountains, as in passing along the surface of the earth from the equator to the poles.

Terrestrial animal life attains its greatest development, both as regards luxuriance and diversity, within the tropics.

Marine animal life attains its greatest development in the colder waters of the polar regions and vicinity.

Man attains his greatest mental development in the temperate zone.

As regards the vertical distribution of life, the fauna of regions between the sea level and 5000 or 7000 feet, resembles, in general, that of the tropics; between the preceding and 15,000 feet, that of the temperate zones.

The boundaries of animal regions are, in general, to be found in the isothermal lines.

As a class, animals appear to possess to but a limited degree the power of living in a climate differing greatly from that in which they were first created.

The fauna of the earth may be conveniently arranged under three heads: the tropical, temperate, and arctic.

The tropical fauna are characterized by the number and diversity of terrestrial species, as well as their size, strength, and sagacity.

In tropical fauna, the mammalia are represented as follows:

Monkeys, by the orang-outang, chimpanzee, gorilla, and baboon.

Flesh-eating mammals, by the lion, tiger, panther, and puma.

Plant-eating mammals, by the elephant, rhinoceros, tapir, hippopotamus, zebra, quagga, giraffe, and camel.

Marsupials, by the kangaroo.

Birds are represented by the condor, ostrich, eagle, ibis, flamingo, cassowary, bird of paradise, peacock, and parrot.

Reptiles, by the crocodile, alligator, iguana, and turtles.

The temperate fauna, though characterized by fewer of the higher species of animals, yet contain many of large size, and among them animals of great use to man.

In temperate fauna, the carnivorous mammalia are represented by the lynx, hyena, wolf, jackal, dog, fox, raccoon, bear, seal, and walrus.

The herbivorous mammalia, by the wild boar, hog, horse, ass, ox, sheep, goat, chamois, moose, elk, reindeer, stag, antelope, buffalo, camel, and llama.

The gnawing mammals, by the beaver, squirrel, rat, and porcupine.

The whale, by the sperm and white whale.

The marsupials, by the kangaroo.

Birds, by the condor, vulture, hawk, eagle, owl, parrot, turkey, pheasant, wren, thrush, robin, nightingale, lark, pelican, and albatross.

The arctic fauna contain but comparatively few large land species; the chief characteristics are numerous smaller furry species.

In the marine arctic fauna numerous species are found, some of which, as the whale, are among the largest in the animal world.

The terrestrial arctic fauna are characterized by the following animals: the white polar bear, the reindeer, the moose, and the musk-ox.

The marine fauna, by the Greenland whale, the seal, and the walrus.

The peculiar distribution of the vegetation of the continents produces corresponding peculiarities in their characteristic fauna.

The North American continent is characterized by the preponderance of its plant-eating mammals. The cause of this peculiarity is to be found in the abundance of its pasture lands.

Fur-bearing animals particularly characterize the northern and central portions of North America.

There are three natural districts of fur-bearing animals in North America: 1. The forest region; 2. The barren grounds; 3. The prairie regions.

The South American continent is especially characterized by the predominance of reptilian life, aquatic birds, and insects. The cause of the peculiarity is traceable to the predominance of the vegetable life over the animal.

The Asiatic continent is especially characterized as being the original home of most of the animals which man has domesticated. The cause of this peculiarity is traceable to the fact that Asia was the primitive home of man himself.

The great deserts of Africa are characterized by the presence of animals which are peculiarly noted for their swiftness of locomotion.

In the remaining portions of Africa, the luxuriant vegetation sustains animals of a larger, bulkier growth; as, for example, the elephant, rhinoceros, hippopotamus, and the giraffe.

Australia is peculiarly characterized by the presence of the marsupials. It is the home of the kangaroo, the most important of the marsupials.

Ethnography treats of the varieties of the human race, and their distribution.

Man has a wider range of distribution than any other animal.

It is believed by most that all the varieties of the human race were originally descended from one family.

Though greatly different in color, size, stature, and intelligence, the general anatomical structure, the basis on which all other animals are classified, is invariably the same, even in the most widely differing races.

The languages of Europe and of a large portion of Asia, appear to owe their origin to one parent nation, which dwelt, during pre-historic time, in the neighborhood of Mount Ararat and Mesopotamia.

The primary races are the Caucasian, the Mongolian, and the Negro.

The secondary races are modifications of the Mongolian: they are the Malay, the American, and the Australian.

The Caucasian race inhabits South-western Asia, Northern Africa, and nearly the whole of Europe.

The Caucasian race may be divided into three branches: the Hamitic, the Semitic, and the Japhetic, or the Indo-Europeans.

The Mongolian race inhabits all of Asia, except a small part of the Malay Peninsula and those portions of the continent occupied by the Caucasians.

The Chinese, Japanese, Esquimaux, Lapps, Finns, Turks, and Magyars, are among the most important of the Mongolians.

The Negro race inhabits all the continent of Africa not occupied by the Caucasians.

The Malay race inhabits the southern part of the Malay Peninsula, Madagascar, and the islands of the Indian and Pacific Oceans.

The Australian race inhabits all the continent of Australia not settled by the whites.

REVIEW QUESTIONS.

Define zöological geography. Fauna.

Why should the distribution of heat and moisture form the true basis for the distribution of animal life?

Distinguish between the horizontal and the vertical distribution of animals.

What difference exists between terrestrial tropical fauna and marine tropical fauna?

Between what limits, in the vertical distribution of animals, do the fauna of a tropical mountain-range resemble that of the tropical horizontal zone? Of the temperate zone?

What lines generally form the boundaries of animal regions?

Which possesses the greater power of acclimation, man or the inferior animals?

State the characteristics of the tropical fauna, naming the principal carnivora, herbivora, cetacea, cheiroptera, marsupials, birds, and reptiles.

State the characteristics of the temperate fauna, naming the principal carnivora, herbivora, rodentia, cetacea, marsupials, birds, and reptiles.

State the characteristics of the arctic fauna, naming the characteristic terrestrial and marine species.

What peculiarities characterize the fauna of North America? What is the cause of these peculiarities?

What are the peculiarities of the fauna of the South American continent? What is the cause of these peculiarities?

What is the main peculiarity of the Asiatic fauna?

Describe the districts of fur-bearing animals of North America. Of Asia.

For what peculiarity are the animals of the deserts of Africa and Arabia noted?

What is the main characteristic of the Australian fauna?

Define ethnography.

What arguments can be adduced to show the probable unity of the human race?

Name the primary races.

Name the secondary races.

Into what three branches may the Caucasian race be divided?

What peoples have descended from the Aryans, or the Indo-Europeans?

Name the principal Celtic nations.

What nations have sprung from the ancient Romans?

What nations have descended from the Germans?

Name the Slavonic nations. The Iranians.

Name the parts of the world inhabited by each of the primary and secondary races.

Describe the peculiarities of each of these races.

Name a few of the peoples which belong to each of the races.

MAP QUESTIONS.

Trace on the map of the Vertical Distribution of Animal Life, the characteristic fauna in those parts of each of the continents, lying between the level of the sea and 5000 feet. Between 5000 and 10,000 feet. Between 10,000 and 15,000 feet. Between 15,000 and 20,000 feet.

Name from the map of the Distribution of Animals, the tropical species of the Americas. Of Africa. Of Asia. Of Australia.

Name, in a similar manner, the temperate and arctic species of the Americas. Of Europe. Africa. Asia. Australia.

In what portions of the world is the seal found? The walrus? The whale?

Trace on the map the southern limit of the polar bear. Of the reindeer. Of monkeys. Of the elephant and rhinoceros. The northern limit of the camel. Of monkeys.

Locate the chief districts of venomous serpents in the eastern and western hemispheres.

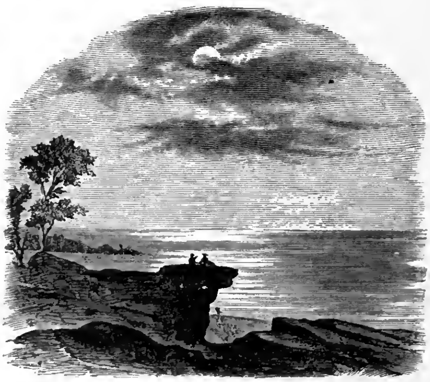
Describe the region of the musk-ox. Of the grizzly bear. Of the buffalo.

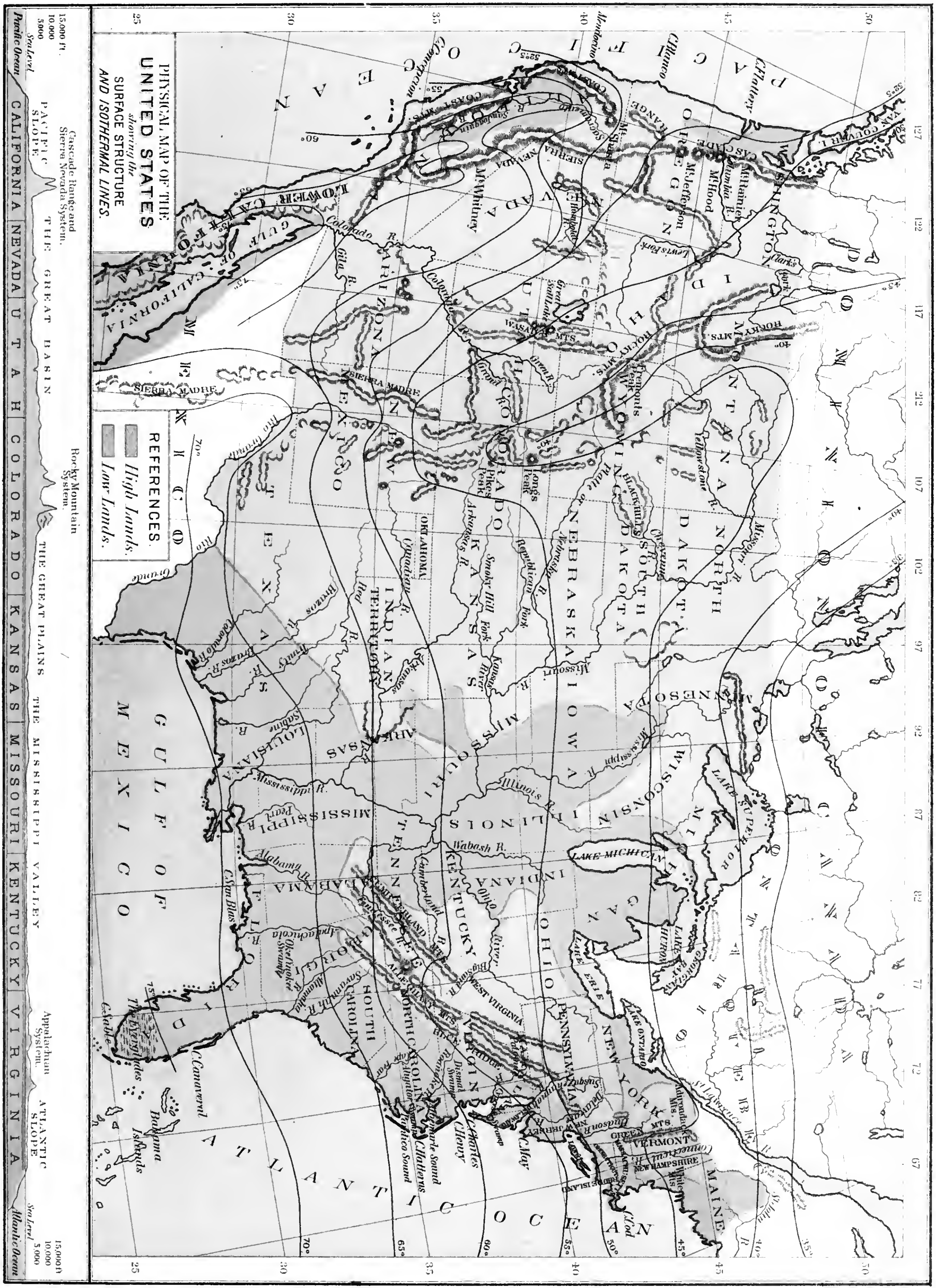
State, from the Ethnographic Map, the portions of the world inhabited by the Caucasian race. The Mongolian race. The Ethiopian race. The Malay race. The American race. The Australian race.

What different peoples dwell north of the arctic circle? South of the tropic of Capricorn?

Trace on the map the northern limit of permanent habitation. The southern limit.

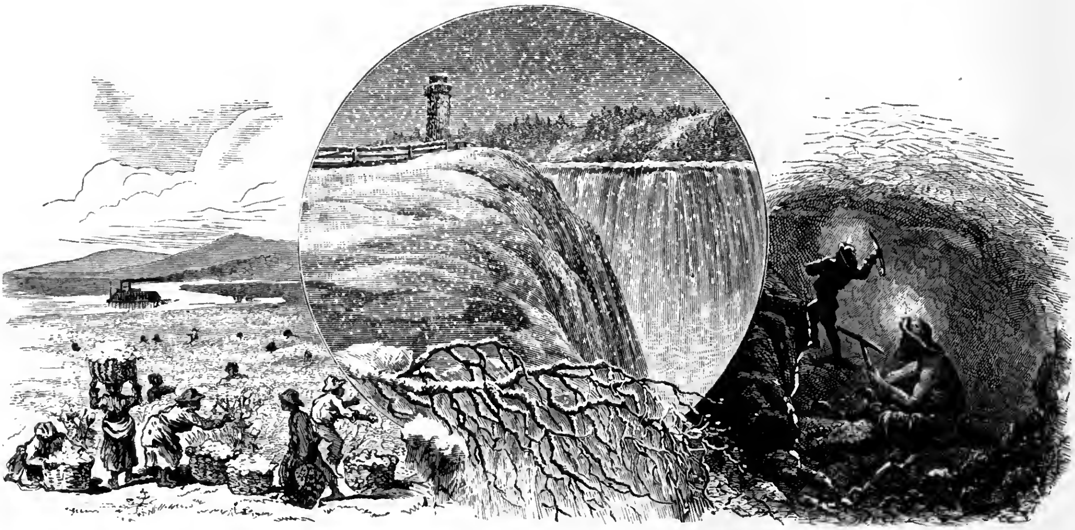
What race inhabits Hindostan? What people? What race inhabits Abyssinia? What people? Greenland? Patagonia? China? Mexico? France and Spain? Northern Norway and Sweden? Arabia? Madagascar?




PHYSICAL MAP OF THE
UNITED STATES
showing the
SURFACE STRUCTURE
AND ISOTHERMAL LINES.
REFERENCES.
High Lands.
Low Lands.

PART VI.

THE PHYSICAL FEATURES OF THE UNITED STATES.



The civilization and development of a country are dependent, in a marked degree, on the peculiarities of its physical features. The soil and climate exert their influence on the vegetable and animal life, and these, in turn, react on man. If proper soil and climate exist; if the peculiarities of the surface structure permit of ready intercommunication, and if extensive deposits of coal and valuable metals occur, the future development of the country is assured.

The physical features of the magnificent domain of the United States are such as seem to destine it to become the theatre of the civilization of the future. The peculiarities of its position and extent, the nature of its soil, the climate, and rainfall, the size and constancy of its navigable rivers, and the extent and variety of its valuable mineral deposits, eminently fit it to sustain a very high order of civilization.

CHAPTER I.

Surface Structure of the United States, exclusive of Alaska.

368. Situation and Extent.—The United States occupies the entire breadth of the North American continent, between lat. 49° N., and 24° 30′ N. and extends from long. 66° 50′ W. from Greenwich, to 124° 31′ W. The total area, exclusive of Alaska, is 3,026,500 square miles.

369. Coast Line.—The coast line is comparatively simple and unbroken. On the east, the Atlantic Ocean extends into the land in three wide curves; on the south, is the deep indentation of the Mexican Gulf; on the west, the land is thrust out into the Pacific in an almost unbroken curve. The total coast line, exclusive of the adjoining islands and Alaska, is about 12,609 miles.

370. Gulfs and Bays.—The principal indentations on the eastern coast are Long Island Sound, Delaware and Chesapeake Bays, and Albemarle and Pamlico Sounds. On the western coast are the Gulf of Georgia and the fine harbor of the Bay of San Francisco.

The Atlantic shores slope gently toward the ocean; the Pacific shores are abrupt.

371. Islands.—The islands of the Atlantic coast are of three distinct classes: those north of Cape Cod are, for the most part, rocky, and are detached portions of the mainland; those south of Cape Cod are generally low and sandy, and are, for the most part, of fluvio-marine formation; those off the coast of Florida are of mangrove formation. On the Pacific coast are the Santa Barbara Islands, a rocky group south-west of California; and Vancouver Island, north-west of Washington.

Fig. 123. View on the Coast of Mount Desert Island, Maine.

372. Mangrove Islands.—Mangrove trees grow in dense jungles, on low muddy shores, in tropical regions. From both trunks and branches the trees throw out air-roots, which spread so as to cover the adjoining spaces in an almost interminable network of roots and branches. The area of surface covered by the trees is still further increased by the curious property which the seeds possess of sprouting while on the tree, subsequently floating away, and afterward affixing themselves to the bottom of the jungle, to form new growths. In this way, the trees form mangrove islands, which at first are not true islands, the trees simply standing above the water by means of their intertwined roots. In course of time, however, sediment, collecting between the roots of the trees, forms islands. These islands are common in the shallow water off the coasts of Florida.

373. Coral Reefs of Florida.—The peninsula of Florida, south of the northern extremity of the Everglades, and probably as far north on the eastern coast as St. Augustine, is, according to Agassiz, a species of coral formation, formed, however, under different conditions than are the coral islands of the Pacific.

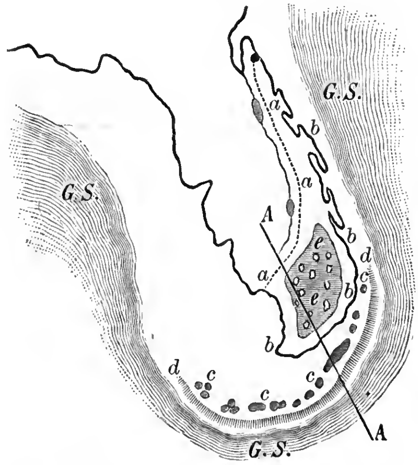


Fig. 124. Florida Reefs and Keys. (LeConte.)

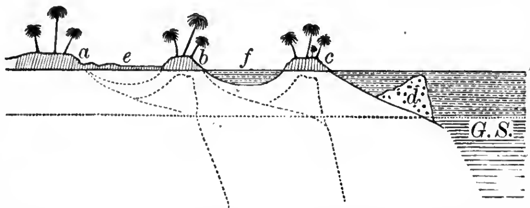


Fig. 125. Everglades, Reefs, and Keys of Florida. (LeConte.)

Figure 124 is a map of Florida with its reefs and keys. Figure 125, is a section along the line A. A. In Fig. 124 the line *a a*, shows what was at one time the limit of the southern coast of Florida. *b b*, is the present limit of the southern coast. *c c*, are the keys, which are low islands. *d d*, is the growing coral reef. *e*, is the Everglades, dotted with islands, called *hummocks*. Between *c c*, and *d d*, is the ship channel. Outside the growing coral reef *d d*, are the profound depths of the Gulf Stream G. S.

The growth of the reef-formations is explained by LeConte as follows (Fig. 125): *a*, was at one time the limit of the southern coast of Florida. *b*, is the present southern coast, which at one time was a coral reef like *d*. Upon *b*, a line of coral islands gradually formed connecting it with the old southern coast *a*. The ship channel between *a*, and *b*, gradually filled up and formed the Everglades *e*. Meanwhile, another reef formed, in the position of the present keys, *c*, the ship channel being between *b*, and *c*. This reef has now grown to be a line of coral islands, and the ship channel, between *b*, and *c*, converted into shoals and mud flats, *f*. The present ship channel is between *c*, and *d*. In course of time the southern coast will extend to the present line of keys, *c*, and the shoal water *f*, will become another Everglades. Outside the present keys *c*, another coral reef *d*, is growing, to which the coast will ultimately extend, and which will mark the limit of the formation, owing to the deep waters of the Gulf Stream, immediately beyond it. In Figure 125, the dotted lines show the successive steps of the formation.

374. Forms of Relief.—The United States is traversed by two distinct mountain-systems: the Pacific System—the predominant system—on the west, and the Appalachian System—the secondary system—on the east.

375. The Pacific System, consists of a broad plateau, traversed by two distinct mountain-systems: the Rocky Mountains, and the Pacific mountain-chains. It embraces about one-third of the entire territory of the United States proper.

376. The Rocky Mountain System, consists of a number of parallel chains connected by numerous cross ranges. They rise from the summits of an elevated plateau, which in some places is fully 7000 feet above the sea. The chains are broken in several places by transverse valleys or passes, traversed by important rivers. The most important of these passes is South Pass, in Wyoming, traversed by the Sweet Water River, a tributary of the Platte. The Missouri, Rio Grande, and other rivers also flow through similar depressions.

The chains are separated into northern and southern sections by a gap occupied by an elevated plateau, over which the Union Pacific Railroad passes.

Among the many lofty peaks of this mountain-system are Long's Peak, 14,050 feet; Pike's Peak, 14,216 feet; and Fremont's Peak, 13,570 feet high.

A remarkable feature of these mountains is the basin-shaped valleys, called parks, formed by transverse ranges connecting the parallel ranges. The most important of these parks are North, South, and Middle Parks. They are nearly rectangular in outline, and are hemmed in by huge mountain-ranges. Each park gives rise to an important river. The rich verdure of these deeply-sunken basins is rendered the more striking by contrast with the desolate mountains surrounding them.

The Yellowstone National Park, in the north-western part of Wyoming, is traversed by some of the head-waters of the Yellowstone River. It is a region of hot springs, deep gorges, high mountain-peaks, and magnificent scenery. It has been set apart by the government for the purposes of a public park.

The Great Plains, an elevated plateau, lie along the eastern side of the Rocky Mountains. They are undulating plains, which slope by almost imperceptible gradations, to the valley of the Mississippi. They are treeless, and near the base of the mountains have but a scanty vegetation. Near the lower part of the slope they merge into prairies, covered with a luxuriant growth of grass.

377. The Pacific Mountain-Chains extend through California, Oregon, and Washington, and, in general, are parallel to the Rocky Mountains. They comprise the Cascade Mountains in Oregon and Washington, and the Sierra Nevada and the Coast Mountains in California.

The famous gold regions of California lie mainly west of the Sierra Nevada and the Coast Mountains.

The loftiest peaks of the Pacific Mountain-chain exceed those of the Rocky Mountains in height. The highest peaks are Mt. Rainier in the Cascade Range, 14,444 feet high; and in the Sierra Nevada Range, Mt. Shasta, 14,482 feet high, and Mt. Whitney, 14,800 feet high.

The culminating point of the Pacific Mountain-chains is Mount St. Elias, in Alaska, which is estimated to be 19,500 feet high.

The Cascade Mountains contain numerous extinct volcanoes.

The Great Basin lies between the Wahsatch on the east. and the Sierra Nevada and Cascade ranges on the west,

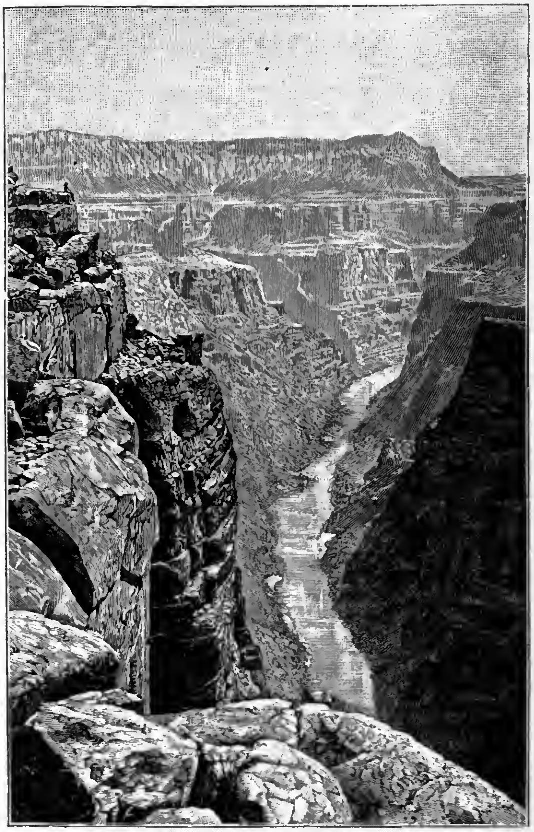


Fig. 126. The Great Cañon of Colorado.

It possesses a true inland drainage. East of the Wahsatch Mountains and the western flanks of the elevated peaks and ranges of Colorado, lies a region drained by the head-waters of the Colorado. This region, together with the country lying in the middle courses of the river, is a wonderful section of country, traversed by streams that have eroded their valleys and flow through deep cañons, some of which are over 6000 feet deep. A view of a part of one of the most noted of these cañons is shown in Fig. 126.

378. The Appalachian System, sometimes called the Alleghany Mountains, extends from Georgia to Maine, nearly parallel to the Atlantic. The chain varies in breadth from 150 to 200 miles. The system consists of an elevated plateau, bearing several mountain-chains, separated by wide valleys. In the northern and southern parts of the chain, where the elevation is the greatest, the system is formed of irregular groups, without any definite direction. In the centre, low parallel chains occur separated by fertile valleys. These valleys generally take the names of the rivers which flow through them.

The system is highest in North Carolina, where Mt. Mitchell, 6707 feet high, forms its culminating point.

Beginning in the north, the system includes the *White Mountains* in New Hampshire, with Mount

Fig. 127. The Natural Bridge (Virginia).

Washington, 6294 feet high; the *Green Mountains*, in Vermont; the *Adirondacks*, in New York, with the culminating peak of Mount Marcy, 5379 feet high; the *Catskill Mountains*, the *Blue Mountains*, the *Alleghanies*, the *Blue Ridge*, the *Cumberland Mountains*, and others.

The Natural Bridge, in Rockbridge County, Virginia, is, from its peculiar formation, an object of interest to tourists.

379. Plains.—There are two great low plains in the United States: the Atlantic Coast Plain and the Plain of the Mississippi Valley.

The Atlantic Coast Plain lies along the eastern flanks of the Appalachian Mountains. It varies in width from 50 to 250 miles. Along the coast the soil is comparatively sandy, and has been formed by the combined action of the rivers and ocean.

The extensive swamps which occur in this region—such as Cypress Swamp, in Delaware, Dismal Swamp, north of Albemarle Sound, Alligator Swamp, between Albemarle and Pamlico Sounds, and Okefinokee Swamp, in Southern Georgia—are of fluvio-marine origin. The Everglades, in Florida, are the result of a coral formation. Farther from the coast, the plain is more elevated; long valleys occur, which are very fertile, particularly near the river bottoms.

The Mississippi Valley lies between the predominant and the secondary mountain-systems. It is over 300,000 square miles in area, and includes some of the most fertile land in the country. Much of it is covered with forests or prairies.

380. River- and Lake-Systems.—The United States is particularly noted for the number and extent of its navigable rivers.

Oceanic Drainage—Atlantic System.—Among the important rivers emptying directly into the Atlantic Ocean are the Penobscot, Merrimac, Connecticut, Hudson, Delaware, Susquehanna,

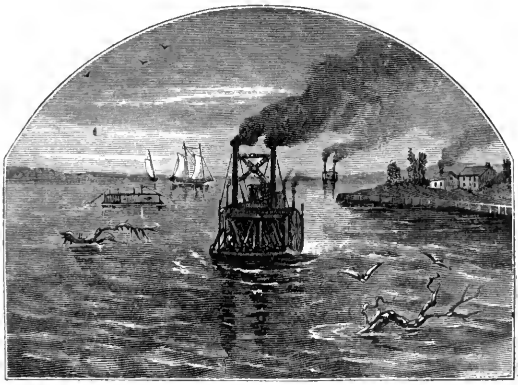


Fig. 128. Scene on the Mississippi.

Roanoke, Cape Fear, Santee, Savannah, Altamaha, and the St. John's.

Of the rivers flowing into the Mexican Gulf, the Appalachicola, Alabama, Mississippi, Sabine, Trinity, Brazos, Colorado, and the Rio Grande are the most important.

The Mississippi, taking its origin in the head-waters of the Missouri—which is the true parent stream—is the longest river in the world, its length being 4490 miles. Its tributaries are, in general, navigable for great distances, and thus afford ready communication with different parts of the basin. The important tributaries of the Mississippi on the west are the Minnesota, the Missouri, the Arkansas, and the Red. On the east, the Wisconsin, the Illinois, and the Ohio.

The Pacific System.—The principal rivers emptying into the Pacific Ocean are the Columbia, Sacramento, San Joaquin, and the Colorado.

381. Inland Drainage.—The rivers and lakes of the Great Basin have no outlet to the ocean, and therefore form true steppe systems. Great Salt and Humboldt lakes are the principal lakes, and the Humboldt and the Reese, the principal rivers.

There are two regions in the United States below the mean level of the sea:

(1.) In the southern part of California, in Soda Valley, 200 feet below the sea.

(2.) Death Valley in Eastern California. These regions are extremely arid.

382. Lake-Systems.—The most important lake-system of the United States lies in the northern part. It includes, among numerous others, five of the largest fresh-water lakes in the world: *Superior*, *Michigan*, *Huron*, *Erie*, and *Ontario*. From their immense extent, they resemble great inland seas.

Numerous *fluviatile or river* lakes occur near the borders of the middle and lower courses of the Mississippi and its tributaries. They are nearly all found in the States west of the Mississippi.

CHAPTER II.

Meteorology.

383. Climate.—The United States, exclusive of Alaska, lies entirely within the limits of the mathematical north temperate zone.

Physical Zones.—As regards the actual distribution of heat, the United States lies between the annual isothermal lines of 40° and 77° Fahr. Its territory therefore embraces two zones of physical climate, the *physical north temperate* and the *physical torrid zones.* The isotherm of 70°, the boundary of the physical torrid zone, passes through Florida, Louisiana, Texas, and Arizona. All of the country south of this line lies in the physical torrid zone; all north of it, in the physical north temperate zone.

The Territory of Alaska lies in the north frigid and north temperate zones.

384. Mean Annual Isotherms.—The following peculiarities in the mean annual distribution of heat, will be seen from a study of the mean annual isotherms on the map (page 141):

The isotherm of 40°, the lowest mean annual temperature, is found in a few elevated districts in New England, in the elevated districts around Lake Superior, and in the higher plateaus of the Rocky Mountains.

The isotherm of 45°, east of the Mississippi, runs slightly north of the 44° of N. lat., and, except in New York, Vermont, and New Hampshire, is nearly parallel with it. In the Dakotas it bends toward the north-west, reaching the northern boundary of the United States in Montana, when it bends suddenly toward the south-east, until it reaches Central Colorado, where, nearly parallel with its southward deflection, it again turns abruptly to the north.

The isotherm of 50° is nearly parallel with the 41° N. lat., until it reaches Colorado, when it bends sharply south to the 36° lat.; then it extends in a nearly direct line toward the north-west, entering the Pacific coast somewhat to the north of Washington.

The isotherm of 55° enters the Atlantic coast at lat. 40°; it then extends south-west to Tennessee; thence northward to Kentucky, from which its course is nearly due west to Indian Territory, when it bends southward to about lat. 34° in New Mexico. From this point it extends in a nearly direct north-westerly course to lat. 41° in Northern California, when it bends sharply to the south, entering the Pacific Ocean at about lat. 36°.

The isotherm of 52.5°, traced only on the western half of the map, starts from the north-western part of New Mexico, and runs in a nearly direct north-westerly course to North-eastern Nevada, when it divides, the northern branch extending to the north-western extremity of Washington, and the southern entering the Pacific in the neighborhood of San Francisco.

The isotherm of 60° enters the Atlantic coast at Norfolk, Virginia; it then trends south-west to Northern Georgia, from which its course is nearly due west until it reaches Indian Territory, when it runs south-west to New Mexico. Here it divides into two branches: the northern extends in irregular curves to lat. 40° in California, when it bends sharply to the south-east, entering the Pacific at about lat. 34°. The southern branch enters the Gulf of California at about lat. 25°.

The isotherm of 70° extends through Northern Florida, Southern Louisiana, and Texas.

The isotherm of 75° extends through Southern Florida.

385. Climatic Contrasts.—*There is a marked contrast between the climate of the eastern and western coasts of the United States. The eastern coast is colder than the western.*

The difference in temperature is greater in the north; the mean annual temperature of the coast, between New Jersey and Maine, is from 52° to

42° Fahr., while on the shores of California, Oregon, and Washington, the mean is nowhere lower than 52°, and in many places is much higher.

In the southern portions of the eastern and western coasts, the contrast is not so decided, owing to the peculiarly cool summers in the western part of the continent.

The Atlantic seaboard is much colder than corresponding latitudes on the western coasts of Europe. For example, the latitude of New York City is about the same as that of Madrid, Naples, and Constantinople; of Boston, the same as that of Rome; of Portland, Maine, the same as that of Marseilles; of Quebec, nearly that of Paris; and yet what a striking difference in their climates!

The western shores of America are, however, quite as warm as those of Europe. Sitka, in lat. 57°, has a winter mean very nearly the same as that of Edinburgh, in the same latitude.

The higher mean annual temperature of the western coasts over that of the eastern will prove of great significance in the future history of the United States, since our western shores will admit of cultivation and settlement for a much greater distance north than will the eastern. "The difference," says Blodget, "covers 12° to 15° of latitude on the coast of the Pacific, and from 5° to 40° on the plains east of the Rocky Mountains.

The sharp contrast between the climáte of the eastern and western shores is caused by the atmospheric and oceanic circulation, which, in both cases, is from *west to east;* hence, the higher temperature of the western shores, on account of the warm, vapor-laden winds from the Pacific, the comparatively heavy rainfall, and the warm ocean currents. The cold Arctic current, which comes from Baffin Bay down the Atlantic seaboard, reduces the mean annual temperature of the eastern coast.

On the south, the Gulf Stream, emerging from between Florida and Cuba, tends to raise the temperature of the southern portions of the seaboard, though its greatest influence is exerted on the distant shores of Europe. On the Pacific coast, the Japan current, after leaving the Asiatic shores, flows southward along the North American coasts, bathing them with its highly heated waters.

386. Constancy of the Climate.—From observations extending back as far as the year 1738, it appears, that from that time, the climate of the United States has undergone no decided change.

387. Distribution of Wind and Rain.—The United States lie in the zone of the *variable winds. Westerly winds, therefore, predominate.*

388. Precipitations.—The domain of the United States is well watered, copious rains falling over nearly all portions of the surface, especially on those which lie east of the predominant mountain-system.

East of the 100th meridian from Greenwich, an average of at least 40 inches, or 3⅓ feet, falls throughout the year. From this large rainfall, it is evident that the evaporation, which supplies the winds with moisture, must take place in the equatorial regions, and that, in general, the upper currents of equatorial winds bring the rain. The open sweep afforded to the winds by the Gulf of Mexico and the Mississippi Valley, increases the rainfall of the Gulf States.

The heaviest annual rainfall is 65 inches, and occurs near the borders of the Gulf States, and along the Pacific seaboard in Washington and Oregon. Along the Atlantic border, it varies from 40 to 45 inches; in the upper half of the Mississippi Valley, it varies from 25 to 40 inches; in the lower half, from 40 to 65 inches; in the upper course of the Missouri and the region of the Yellowstone, from 20 to 22 inches; in portions of the Great Basin the rainfall is very limited, being but from 5 to 10 inches.

As regards its distribution *in time,* rain is possible at all seasons of the year over most of the country; over some portions, however, it is periodical in character, these districts having a rainy and a dry season.

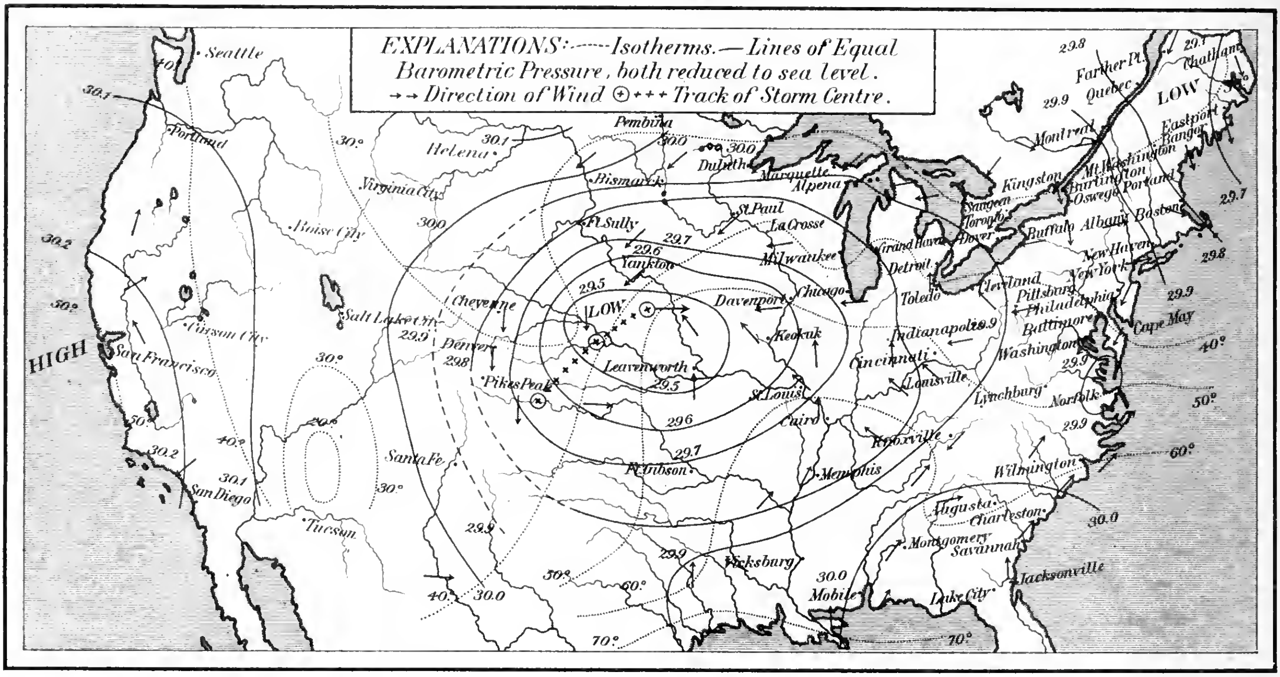
East of the Mississippi River, rain may fall at any time of the year. Near the Atlantic coast, rain is especially abundant in the spring.

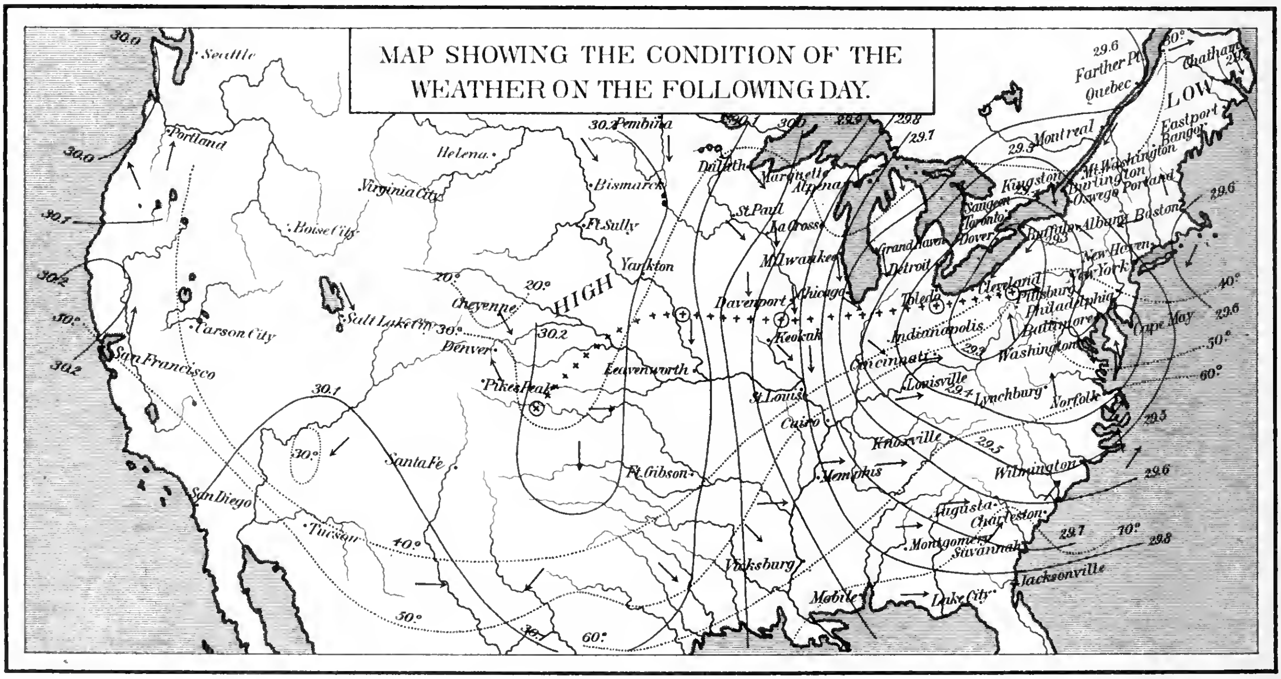
West of the Mississippi the rainfall is more irregular. In Washington, on the Pacific coast, rain may fall at any time during the year. On other parts of the Pacific coast, rain is most frequent in winter; during the summer, it is either scanty or wholly absent. This periodicity in the distribution occurs mainly in the region near the coast. In the interior, the precipitation is more irregular.

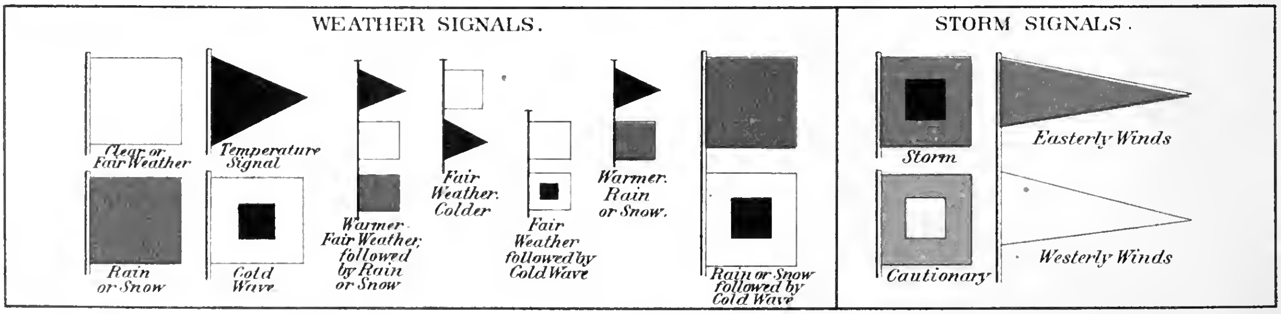
389. The Weather Bureau.—Considerable light has been thrown on the meteorological conditions of the United States by the operations of the "Weather Bureau."

The Weather Bureau was established by an Act of Congress in February, 1870, authorizing the Secretary of War to establish and equip stations in different parts of the country, where such simultaneous observations of the meteorological conditions of the atmosphere could be taken, as would enable the Department to give timely notice to all important ports on the Atlantic

P. 148. WEATHER MAP, SHOWING CONDITION OF THE WEATHER ON A CERTAIN DAY IN APRIL.







coast and Great Lakes of the approach of dangerous storms, and to collect such information as would be of value to shipping and other interests.

In 1890, the direction of the Weather Bureau was, by Act of Congress, taken from the War Department and transferred to the Department of Agriculture.

There are about 500 stations established by the Weather Bureau in different sections of the United States. At these stations there are trained and intelligent observers, who several times each day are simultaneously required to make careful observations of the temperature, humidity, and pressure of the air, the direction and force of the wind, the clearness or cloudiness of the sky, and the amount of rain or snow that has fallen during a given time.

These observations are telegraphed to the Central Office at Washington, so that the Bureau is enabled to see the actual meteorological conditions which exist throughout the country at any given time, and from such knowledge, guided by previous experience, to prepare "synopses" of the weather and "indications," or forecasts.

For the preparation of the "indications" the officer in charge prepares *a number of graphic charts*, based on the various data telegraphed to the Central Office, as the result of the simultaneous observations at the different stations. These charts exhibit the actual meteorological conditions that then exist, those that existed during the previous eight hours, and the previous twenty-four hours, and the conditions normal for the place at that particular time of the year. The data shown on these charts include the temperature, barometric pressure, humidity of the air, precipitation, condition of sky, force and direction of wind, etc. The "indications" are telegraphed to the press throughout the country. In general about 85 per cent. of these indications are verified.

It should be borne in mind, in considering this very large percentage of verified forecasts, that the indications are predicted for extended areas, and, therefore, although the change may not have occurred in some limited section of the predicted area, it may have occurred in nearly all the other portions of the region.

Changes in the Weather—Passage of a Great Storm.—Since nearly all the great storms of the United States are species of cyclones, that move over the country in a general easterly direction, when such a storm is once started it is not a difficult matter to predict its general path, and thus foretell coming changes in the weather.

The principal elements of uncertainty are the exact path in which the storm will move over the country, and the velocity of such motion. These the bureau can predict, approximately, from a comparison of all the previous storms of which it has records.

The whirling direction of the wind in the Northern Hemisphere is in the opposite direction to that of the hands of a watch. Therefore, as the eastern side of a storm approaches any section of country, the winds blow generally from the south toward the north. The approach of a cyclone is generally attended by a fall of rain or snow. As the cyclone moves onward, and its western side passes over any locality, the general direction of the wind is from the north to the south. The passing of the cyclone is generally attended by clearing, cooler weather.

Cold Waves.—On the edges of a cyclone the barometer is high. When one storm follows another at a short interval, the area of high barometer between them causes the wind to blow in all directions from the centre of high barometer, and a cyclonic movement of the air is thus established, possessing a progressive motion like a true cyclone. Since the direction of rotation of such a storm is opposite to that of a cyclone, it is called an *anti-cyclone*. Cold waves generally originate in anti-cyclones.

The Weather Signals consist of signal-flags displayed at important stations on the various lines of railroads and at other prominent places, and are designed to indicate the probable weather and temperature of the coming day.

The temperature signal indicates warmer weather when placed above the other flags, and colder weather when placed below them. The cold-wave flag indicates a decided fall in temperature.

The Storm Signals are displayed at all ports on the Great Lakes or the Atlantic seaboard whenever it is considered probable that within twelve hours there will be experienced at those ports, or within one hundred miles thereof, a wind dangerous to navigation. The cautionary signal is displayed when the winds expected will be severe, but not dangerous to well-equipped vessels.

In order to extend the benefits of the "indications" to the agricultural districts, farmers' bulletins, containing forecasts, are issued daily.

To reach the different cities, towns, and villages, and the hamlets of the rural districts, the indications, or forecasts, are telegraphed every midnight from the Central Office to centres of distribution, situated in different States. These reports are at once printed at each of these distributing stations, enclosed in envelopes, and forwarded to every post-office which can be reached by the swiftest mail facilities by 2 P.M. of the next day. Great benefit is thus conferred on agricultural interests.

Warnings of coming floods, movements of river ice, sudden or unusual change of level in rivers, are also given as the occasion warrants. The warning is given whenever the water rises above a certain level, called the *danger level*.

Another series of reports are for the benefit of internal navigation. They consist in the announcement, from day to day, of such changes of temperature for different sections of the country as would be likely either to stop navigation by the freezing of the canals, or temporarily to open them sufficiently to enable ice-bound vessels to be pressed forward to the termini of the canals.

The value of the Weather Bureau can scarcely be overestimated; the saving of shipping effected by the timely warning of a single severe storm may more than pay the entire expenses of the bureau for a large portion of the year. We append the following résumé of the work of the bureau:

(1.) The announcement of probable weather changes by the publication of "indications."

(2.) The timely warning of the approach of severe storms.

(3). The display of signals indicating coming changes in the weather.

(4). The publication of farmers' bulletins.

(5.) The river and canal reports.

(6.) The display of symbol-maps, showing the actual state of the weather throughout the entire country.

(7.) The publication of daily weather maps, monthly charts, and charts which give the results of the observations of years.

(8.) The publication of cotton-region reports, embracing reports of rainfall and maximum and minimum temperature throughout the cotton districts from April 1 to October 31.

The International Weather Service.—The success of the meteorological observations of the U. S. Weather Bureau has led to the establishment of stations for simultaneous observations over a large portion of the northern hemisphere and some stations in the southern hemisphere. By simultaneous observations of the meteorological conditions of the whole earth, many things yet unknown as to weather predictions are likely to be discovered.

Tornadoes resemble cyclones in that they are whirling motions of the air. The area over

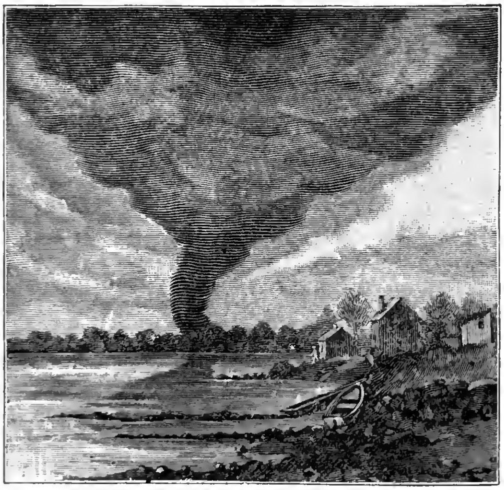


Fig. 129. A Tornado.

which they extend is more limited, but the velocity of the wind is higher than in cyclones, and, therefore, their destructive power is very great. When they pass over any section of country they leave devastation and ruin in their track.

Tornadoes are of frequent occurrence in the central and western portions of the Mississippi Valley.

Tornadoes have their origin in a rotary motion imparted to a mass of warm moist air that is temporarily imprisoned below a mass of colder air. The whirling motions begin at the upper extremity of the column, near the cold air, and gradually extend downwards. This produces the characteristic inverted funnel-shaped mass of dark cloud by which the approach of a tornado is generally heralded.

The path of the tornado, like that of the cyclone, is generally eastward.

Weather Maps.—The actual condition of the weather over the United States, on any day, is represented in weather maps published by the bureau. Two such maps are shown on page 148. The upper map shows the meteorological conditions prevailing on a certain day in April. On that day an area of low barometer existed in Colorado, Nebraska, and Kansas, within which the barometer was below 29.5 inches, as shown by the isobar, or line of mean barometric pressure, of 29.5. The country around this area had a gradually increasing barometric pressure, as indicated by the successive isobars 29.6, 29.7, 29.8, 29.9, etc. At the same time a storm was moving toward the north-east, as shown by the line of crosses. The rate of progress of the storm being known, the bureau issued the following

Indications.

For *New England*, fair weather followed by light rains to-morrow, north to east winds, slight rise in temperature.

For the *Middle Atlantic States*, increasing cloudiness and rain, winds shifting to east and south, slightly warmer weather, lower barometer.

For the *South Atlantic States*, local rains, warmer, partly cloudy weather, south-east to south-west winds, lower barometer.

For the *East Gulf States*, threatening weather and rain, followed by clearing weather, southerly to westerly winds, slight rise in temperature, followed in west portion by a slight fall in temperature.

For the *West Gulf States*, local rains, followed by clearing weather, winds shifting to west and north, nearly stationary, followed by lower temperature, and rising barometer to-morrow.

For *Tennessee* and the *Ohio Valley*, cloudy weather and rain, southerly to westerly winds, rising temperature, falling barometer and severe local storms, followed to-morrow in west portion by cooler weather and higher barometer.

For the *Lower Lake Region*, threatening weather and rain, east to south winds, lower barometer and rising temperature.

For the *Upper Lake Region*, threatening weather, with rain or snow, north-easterly winds becoming variable, falling followed by rising barometer, slight rise, followed by falling temperature.

For the *Upper Mississippi Valley*, threatening weather and rain, severe local storms, winds shifting to west and north, followed by higher barometer and colder weather.

For the *Missouri Valley*, rain or snow, generally colder, cloudy followed by partly cloudy weather, dangerous local storms in southern portion, winds shifting to north and west, with colder weather and higher barometer.

Light rains are indicated to-morrow for New England. and the Middle Atlantic States with warmer weather. Clearing and fair weather is indicated for the West Gulf States and thence northward over the Upper Mississippi, Missouri Valleys, and Lake Region.

The Ohio River, Cumberland, Tennessee, and the Mississippi at St. Louis, Cairo, Vicksburg, and New Orleans, will continue slowly falling.

Cautionary signals continue at Milwaukee, Chicago, Grand Haven, Detroit, Toledo, Sandusky, Cleveland, Erie, and Buffalo.

The lower map shows the actual conditions of the weather on the following day. The area of low barometer, or storm-centre, has moved eastward and the storm is now central over Western Pennsylvania and the adjoining States. The actual condition of the weather, showing the correctness of the predictions, will be seen from an inspection of the following synopsis issued by the bureau:

Synopsis for the Past Twenty-four Hours.

The severe storm which was central in the Lower Missouri Valley yesterday morning moved directly east, causing dangerous gales on the Lakes and general rains in the Southern States, the Middle States, and the Ohio Valley. Snow and rain continue in the Lake Region this morning. Threatening weather is reported from New England, and colder, fair weather from the north-west and south-west. The temperature has fallen about 10° in the Mississippi, Ohio, and Missouri Valleys and Upper Lake Region, with north to west winds; and it has risen slightly in the districts on the Atlantic coast, with north-easterly winds in New England and on the Middle Atlantic coast, and south-westerly winds in the South Atlantic States. The barometer is unusually low near Pittsburg, and it is highest in Nebraska. A light norther prevails on the Texas coast.

CHAPTER III.

Vegetable and Animal Life.

390. Vegetation.—The distribution of vegetation throughout the United States is in accordance with the distribution of the rainfall. Four characteristic plant regions are found: the Forest, the Prairie, the Steppe, and the Pacific Region.

391. The Forest Region.—The chief requisite of forest growth—an abundant rainfall, well distributed throughout the year or during the time the trees are growing—is found especially in the country east of the Mississippi, where luxuriant forests exist, unless removed by civilization.

The pine, spruce, hemlock, fir, larch, juniper, and deciduous trees, such as the beech, maple, birch, alder, and poplar, are common in the North.

Fig. 130. Scene in a Pine Woods.

Deciduous trees characterize the middle portions of the forest region. In the number and variety of its species, the oak is peculiarly characteristic of the middle part of the forest region.

In the southern portion of the forest region evergreen trees, such as the live-oak and the magnolia, are characteristic.

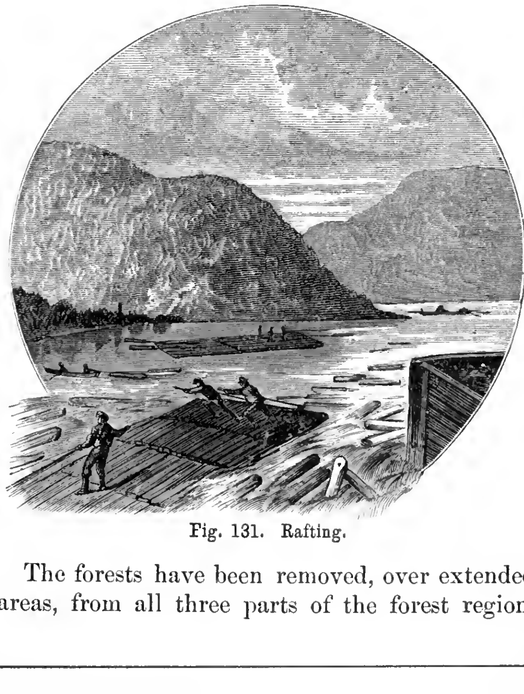


Fig. 131. Rafting.

The forests have been removed, over extended areas, from all three parts of the forest region.

The cut logs, when the river-courses are sufficiently large, are transported to different sections of the country in huge rafts.

392. The Prairie Region.—West of the Mississippi Valley, to the Plateau of the Great Plains, the comparatively scanty rainfall produces extensive prairies, covered with grasses and flowering herbs. Forests are wanting, except along the river-courses.

393. The Steppe Region.—From the western limits of the Great Plains to the Sierra Nevada and Cascade ranges, lie the elevated plateaus of the predominant mountain-system. Here the rainfall is irregular and scanty, and the vegetation presents the peculiarities of a true steppe. But few species of plants occur; the cactus and wild sage are characteristic.

394. The Pacific Region.—From the western limits of the steppe region to the Pacific coast, lies a region whose features, in some respects, resemble those of the forest region. In Washington and Oregon dense forests of fir and spruce trees occur. The cedar, larch, maple, oak, and chestnut are common. In California the periodical rainfall nearly excludes the forest from the valleys and plains; but on the mountain-slopes, where rains are more frequent, well-marked forests abound. The pine, fir, and oak are characteristic.

On the slopes of the coast mountains and the Sierra Nevada and Cascade Ranges, dense forests of pine and fir trees are found. In some parts of these regions the trees frequently attain an immense size, many of them exceeding 300 feet in height. The largest are the celebrated "mammoth trees of California," a species of pine. Some of these trees are 350 feet high, and have a circumference of 110 feet at the base. In some of the fallen trees, the hollow, decayed trunks readily permit the passage of a man and horse.

395. Animal Life.—The large animals now found in the United States are principally those which have been domesticated, such as the horse, cow, sheep, mule, goat, and the dog.

In some of the sparsely-settled regions of the East, and over large areas in the West, a few wild animals are yet to be found. In parts of the Appalachian system, the black bear, panther, and deer are found. The moose is found in the northern parts of the United States. The immense herds of buffalo that once roved over the plains west of the Mississippi are nearly extinct. The grizzly bear and the wolf are found on the mountains of the Pacific slope.

In the South, the warm, sluggish waters of the lower courses of the rivers and swamps, harbor numerous alligators.

A number of species of serpents occur, but only two, the rattlesnake and the copperhead, are venomous.

The manatee, or sea-cow, a curious herbivorous animal with paddle-like legs, found in the shallow waters of the coast of Florida, sometimes attains a length of ten feet.

Some species of the manatee in the North Pacific, off Alaska, reach thirty feet in length.

CHAPTER IV.

Agricultural and Mineral Productions.

396. Agricultural Productions.*—The principal agricultural productions of the United States are wheat, corn, rye, oats, barley, buckwheat, hay, hops, potatoes, flax, tobacco, rice, cotton, and sugar.

397. The Cereals, *wheat, corn, rye, oats, barley,* and *buckwheat,* are grown principally north of the 36° of north latitude. According to the census of 1890, the States giving the largest yield of corn were Iowa, Illinois, and Kansas, while those yielding the most wheat were Minnesota, Illinois, and Indiana.

The yield of corn is greater than that of any other cereal; the corn-crop of the year 1890, in the United

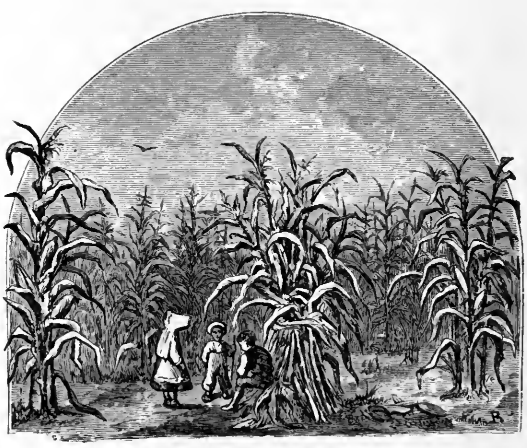


Fig. 132. Corn-Field.

States, amounted to 1,489,970,000 bushels. The wheat-crop of 1890 amounted to 392,262,000 bushels.

* For Synopsis of Census Reports, see Table, page 171.

398. Tobacco and Flax are raised in large quantities in various sections of the country.

The principal tobacco-producing States are Kentucky, Virginia, Pennsylvania, Ohio, Tennessee, and North Carolina.

The entire yield of tobacco in 1888 was 565,795,000 pounds.

Fig. 133. Tobacco Field.

The principal flax-producing States are Minnesota, Iowa, South Dakota, and Nebraska.

The total value of flax-products in 1889 was $10,436,228.

399. Cotton, Rice, and Sugar are cultivated mainly south of the 36° north latitude.

The principal cotton-producing States are Texas, Mississippi, Alabama, South Carolina, Georgia, Arkansas, and Louisiana.

Fig. 134. Cotton.

The cotton-crop of the year 1891 in the United States amounted to 8,655,518 bales, of an average net weight of 440 pounds per bale.

400. The principal rice-producing States are South Carolina, Louisiana, Georgia, and North Carolina. The rice-fields are confined to low, flat, marshy tracts, near the coast or river bottoms.

Fig. 135. Rice Swamp.

The principal sugar-producing State is Louisiana, the plantations being confined mainly to the rich lands in the neighborhood of the Mississippi Delta. Sugar is also grown in South Carolina, Tennessee, and Texas.

Fig. 136. Sugar-Cane Field.

In 1889, Louisiana produced 287,490,271 pounds of cane-sugar.

More than two million gallons of sorghum molasses were produced by Missouri, Tennessee, Kentucky, Illinois, and Iowa in 1889.

Maple-sugar is produced in Vermont, New York, Ohio, New Hampshire, Michigan, and Indiana. The yield of Vermont in one year was 8,894,302 pounds.

401. Mineral Productions.—The United States are particularly noted for the richness and variety of their mineral deposits. Nearly all the important metals are found in various portions of the country, some of the deposits extending over areas of enormous extent.

402. Precious Metals.—Gold, silver, and platinum occur. The deposits of gold and silver are large.

Gold.—The principal deposits of gold occur in the mountainous districts in the eastern and western portions of the country. The Californian region, which embraces the entire western coast and much of the country as far east as the Great Plains, is the richest. The deposits are especially valuable in the basins of the Sacramento and San Joaquin Rivers. Gold is found either in quartz veins or in alluvial deposits.

Silver is found either in the gold-fields already mentioned, or in deposits of galena, one of the most valuable ores of lead. It also occurs pure or native in the copper regions of Lakes Superior and Michigan.

Platinum has been found in small quantities in both the eastern and western portions of the country.

403. Ordinary Metals.—Iron, copper, zinc, and lead occur in various portions of the eastern, central, and western sections of the country.

Iron, which intrinsically is the most valuable of all the metals, is, perhaps, the most widely distributed. Valuable deposits of various iron ores, mainly oxides and carbonates, occur in many parts of the country. The deposits are exceedingly rich in Northern Michigan and Wisconsin; in the neighborhood of the Adirondacks in New York; in Pennsylvania; in Missouri, where the deposits at one time actually formed two mountains of iron; in the district of Lake Superior; in Alabama, and elsewhere. The deposits in Pennsylvania are the most valuable, from their vicinity to beds of coal and limestone, which are necessary for the reduction of the ore.

Copper occurs in large quantities in the eastern, western, and central sections of the country. The ores are principally sulphides or oxides, or the native or metallic copper. The most valuable deposits are found in the neighborhood of Keweenaw Point, Lake Superior, where large beds of the native material occur.

Zinc.—The most valuable deposits are found in Missouri, Wisconsin, and Kansas. It also occurs in the Atlantic States, from Maine to Virginia.

Lead.—Valuable deposits are found in the East, from Maine to North Carolina. The largest and richest districts, however, are in the interior, in Colorado and Utah, where it occurs with silver, and in the Mississippi Valley; in Wisconsin, Iowa, Illinois, and Missouri.

404. Among other valuable metals, **tin, mercury, chromium, nickel, cobalt, antimony, bismuth, manganese,** are found in small quantities.

Tin occurs in limited quantities both in the East and in the West. So far as is known, the deposits are richest in the Black Hills in Dakota.

Mercury is found either pure or in combination. The principal ore is the sulphide of mercury or cinnabar. The deposits in California are the most important.

Chromium is found in moderately large quantities in various portions of the Atlantic States, as far south as Virginia.

Nickel, cobalt, antimony, bismuth, and manganese are found in limited quantities.

405. Coal.—The coal-fields of the United States are the richest in the world. Immense deposits occur in the eastern, central, and western sections of the country. So far as is known, the eastern coal-field, which covers portions of Pennsylvania, Ohio, Virginia, Kentucky, Tennessee, and Alabama, is the most extensive.

Fig. 137. Coal-Mine.

Other coal-fields occur in Illinois and Missouri, in Texas, Michigan, Rhode Island, and New Brunswick and Nova Scotia.

The area of the coal-fields of Western Europe is estimated by Dana at about 20,000 square miles, while the total area of those of the United States probably exceeds 125,000 square miles. In the United States, Pennsylvania possesses the most extensive and the richest deposits, the total area of the deposits in this State being nearly 20,000 square miles, or equal to those of Western Europe. The richness of the American coal-fields cannot fail to exert an important influence on the future development of the country.

406. Peat-Bogs of Massachusetts.—Peat consists of a black, carbonaceous deposit which accumulates in badly-drained regions of humid climates. The surfaces of the peat-marshes are often covered with a thin crust, formed by the interlacing roots of vegetable growths. Below this crust is a treacherous, oozy quagmire.

When peat is dried it is suitable for fuel. Dana estimates that Massachusetts contains fifteen billion cubic feet of peat. Large deposits occur in the Great Dismal Swamp, in North Carolina and Virginia.

407. Petroleum, or Coal Oil, is found in various sections. The most valuable deposits occur in a region embracing Western Pennsylvania, Virginia, Ohio, and Michigan. Petroleum is found also in the West.

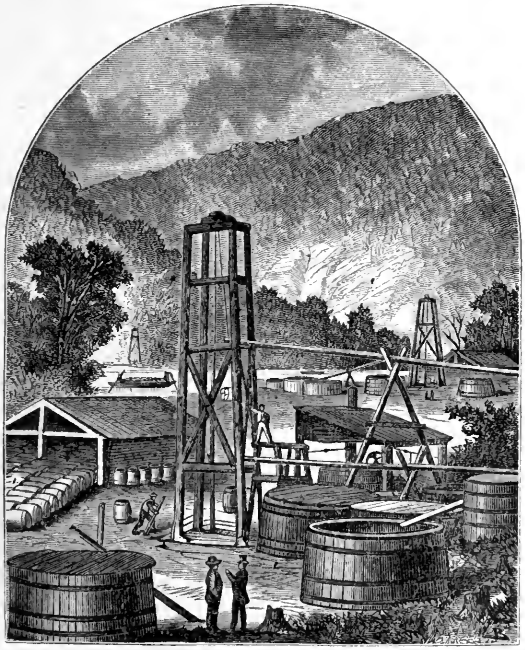


Fig. 138. Oil Well and Tank.

The oil is obtained by boring. The wells so produced are similar to artesian wells, except in the material discharged. In many instances the oil issues in powerful streams, which continue to flow for considerable periods. The crude oil is generally stored in huge tanks, from which it is transferred to barrels or iron tanks for transportation. Much is also distributed for great distances through lines of pipes called pipe-lines. For most commercial uses it is necessary to refine or purify the oil.

408. Natural Gas.—Accumulations of *natural or rock-gas* occur in nearly all portions of the United States, but such deposits are especially rich in the regions where coal oil is found. Western Pennsylvania, and the adjoining States, yield great quantities of such gas.

The gas is obtained by borings similar to those made for artesian wells or coal-oil wells. From the gas wells thus formed the gas issues forth with great velocity. When lighted it burns with a flame similar to that of ordinary illuminating gas. Like ordinary gas it burns with a pale bluish flame when mixed with air, and affords an excellent source of artificial heat.

Natural gas has been known for many years past, but it is only recently that its great extent and quantity have been ascertained. In many districts—notably in the city of Pittsburgh and vicinity—natural gas has practically superseded illuminating gas as a source of light, and has almost entirely replaced ordinary coal as a source of heat. The value of such a natural product in any manufacturing centre can scarcely be overestimated, and its successful introduction in any locality has in all cases been attended with a marked growth in the extent and variety of its manufactures. Although such deposits must in perhaps a comparatively short time become exhausted, as yet they show but little signs of failure.

The gas escapes from the well under great pressure. Before its delivery to consumers, through pipes like ordinary gas-pipes, the pressure is reduced by suitable contrivances; so that its consumption is not attended with any greater risk than that attending ordinary illuminating gas.

409. Salt.—Beds of rock-salt occur in Louisiana, Virginia, and in various parts of the West. Large quantities are obtained by evaporating the waters of saline or brine springs. These are of common occurrence. The most valuable are found in New York, in the neighborhood of Salina and Syracuse; in Virginia, Michigan, Kentucky, and in the Far West.

410. Building Stones.—Large deposits of valuable building stones are found in all parts of the country. Among the most common are various kinds of sandstone, marble, granite, slate, magnesian limestone, serpentine, gneiss, and mica schist. Valuable deposits of clay occur, from which excellent bricks are made.

CHAPTER V.

Alaska.

411. Extent of Territory.—The Territory of Alaska, now a part of the domain of the United States, embraces the north-western part of the North American Continent, and extends south from the shores of the Arctic Ocean to about 54° of N. lat. The main part of the Territory lies west of the 141° E. long. from Greenwich. South of Mt. St. Elias, however, it embraces a narrow strip extending south-eastwardly along the coast of British Columbia.

The Territory of Alaska embraces an area of about 530,000 miles, or, approximately, about one-sixth of the whole area of the remainder of the domain of the United States. This country was purchased from Russia by the United States in 1867, at a cost of $7,200,000.

Indentations of the Coast.—The coast-line of Alaska is exceedingly irregular, its entire length amounting to as much as 8000 miles. The shores of the Arctic are the least indented. The western and southern coasts are deeply indented.

Behring Sea and Straits separate Alaska from Asia. The Pacific Ocean enters the wide curve of the southern coast as the Gulf of Alaska. Smaller indentations on the western coasts are found in Norton Sound, Kuskovitch Bay, Bristol Bay, and in the numerous bays and inlets on the southern coasts, in which true fiords occur.

412. Islands.—Numerous islands lie off the western and southern coasts. The principal of these are St. Lawrence Island and Nunivak, on the western coast; the Aleutian Islands, which extend in a curve from the Alaskan Peninsula nearly to Kamtchatka; Afognak and Kadiak islands, off the southern shores of the peninsula; and Baranoff, Chichagof and Prince of Wales islands off the south-eastern shores.

413. Surface Structure.—The northern portions of Alaska are low and flat, and the plains, drained by a few small, sluggish streams, are, for the most part, frozen moor-lands, similar to the tundras of Northern Siberia. They form a dreary, desolate country, for the greater part unexplored, covered during the brief summer by a comparatively dense growth of grasses.

The rest of Alaska is generally mountainous, being traversed by prolongations of the Pacific Mountain-System. The highest elevations are those of the south-eastern coast, Mt. St. Elias being 19,500 feet above the level of the sea. Mts. Crillon and Fairweather are scarcely inferior in height. These mountains contain numerous glaciers which descend nearly to the level of the sea. The chain of the Aleutian Islands is mountainous, and, like the mountains of the south-western coast, contains many volcanic peaks.

414. Drainage System.—The principal river of Alaska is the Yukon, which, so far as known, has a length of at least 2000 miles. It is one of the largest rivers in North America, so far as the volume of its discharge is concerned, which appears to be as great as that of the Mississippi. In some portions of its lower course it is, in places, 20 miles wide. An extensive delta formation occurs at the mouth of the river. The Lewis and the White, its principal tributaries, are situated near the head-waters of the Yukon, in the Dominion of Canada.

The Kuskovim is the only other important river. Unlike the delta-mouth of the Yukon, the Kuskovim discharges its waters into Behring Sea through a wide estuary. The spring tides sometimes rise in this estuary to the height of over 50 feet.

The glaciers of the south-eastern coast feed a number of lakes, so near together as to permit the establishment of portage-routes of travel.

415. Climate.—The climate of Alaska is, generally, cold and wet, although the influence of the Japan Current, and the westerly winds and rain, render the mean annual temperature much warmer than corresponding latitudes in the interior, or even on the eastern coasts of the North American Continent. Fogs and rains are frequent. The annual rainfall at Sitka, on Baranoff Island, is about 85 inches.

416. Vegetation.—Dense grasses cover portions of the tundras, river valleys, and hillsides during the brief summer. The wet climate, however, renders the curing of hay a difficult matter, and, consequently, the rearing of cattle is attended with difficulty.

Portions of the lower mountainous slopes and river valleys are covered with forests of yellow cedar and spruce. In the greater part of the

Territory no timber grows at an altitude greater than 1000 feet above the sea. Turnips, potatoes, and radishes have been cultivated in southern portions of the Territory with fair success.

417. Animal Life.—The rivers are visited during the breeding season by myriads of salmon. This fish forms the principal food of the inhabitants, who, at the beginning of the season, desert the interior for the banks of the rivers. Halibut, herring, codfish, and mackerel, are caught off the coasts of the Territory.

The fur seal, the walrus, and the sea-otter are caught in great numbers for their valuable fur. The whale is found in the Arctic waters of the northern coast. The polar bear, the brown bear, the mink, the black or silver fox, the moose, and the reindeer are also found in the Territory. Dense swarms of bloodthirsty mosquitoes and black flies occur in nearly all parts of the country.

418. Minerals.—Beds of coal of an inferior quality have been discovered in various parts of the country. Deposits of silver, gold, copper, lead, and cinnabar also occur.

419. Inhabitants.—The inhabitants of Alaska consist principally of the Esquimaux or Innuit, the Indians, and the Aleuts, or the inhabitants of the Aleutian Islands, the Creoles or Russian half-breeds, and the inhabitants of the remaining archipelagoes, together with a few whites.

Sitka, on Baranoff Island, is the principal settlement.

SYLLABUS.

The area of the United States, exclusive of Alaska, is about 3,000,000 square miles.

The coast line is comparatively simple and unbroken. The principal indentations on the east are Long Island Sound, Delaware and Chesapeake Bays, and Albemarle and Pamlico Sounds; on the west, the Gulf of Georgia and the Bay of San Francisco.

The slope of the Atlantic shores is gradual; that of the Pacific shores is abrupt.

On the Atlantic coast, the islands north of Cape Cod are for the most part rocky; those south of Cape Cod are generally low and sandy.

Mangrove islands are formed by sediment collecting around the closely intertwined roots of mangrove trees. These islands occur in the shallow waters off the coast of Florida.

Nearly all of Florida, south of the Everglades, and probably as far north on the eastern coast as St. Augustine, consists of a peculiar variety of coral formation.

The Pacific system is the predominant mountain-system; the Appalachian system is the secondary system.

The Pacific system consists of the Rocky Mountains, the Sierra Nevada, the Cascade, and the Coast Mountains.

The highest peaks are found in the Cascade Mountains.

Portions of the Pacific Mountain ranges contain extinct volcanoes.

The Appalachian system, or the system of the Alleghanies, includes the White Mountains, the Green Mountains, the Adirondacks, the Catskills, the Blue Ridge, and the Cumberland Mountains.

There are two great low plains in the United States: the Atlantic Coast Plain and the Plain of the Mississippi Valley.

The principal rivers draining into the Atlantic Ocean are the Penobscot, Merrimac, Connecticut, Hudson, Delaware, Susquehanna, Roanoke, Cape Fear, Santee, Savannah, Altamaha, and St. John's.

The principal rivers draining into the Mexican Gulf are the Appalachicola, Alabama, Mississippi, Sabine, Trinity, Brazos, Colorado, and the Rio Grande.

The principal rivers draining into the Pacific Ocean are the Columbia, Sacramento, San Joaquin, and the Colorado.

The Great Basin, between the Wahsatch and the Sierra Nevada Mountains, has an inland drainage.

Soda Valley, in Southern California, and Death Valley, in Eastern California, are below the level of the sea.

The Great Lakes, Superior, Michigan, Huron, Erie, and Ontario, form the largest system of fresh-water lakes in the world.

The United States extends from the isotherm of 40° Fahr. to 77° Fahr., and therefore lies in the physical north temperate and the torrid zones.

A marked contrast exists between the temperature of the eastern and the western coasts of the northern half of the country. The eastern coasts are colder than the western.

The greater warmth of the western coasts is caused by warm ocean currents, westerly winds, and heavy rainfalls.

The Atlantic seaboard is colder than corresponding latitudes on the western shores of Europe or on the western shores of the United States.

From observations dating back to the year 1738 it appears that from that time the climate of the United States has undergone no decided change.

The United States lies in the zone of the variable winds; westerly winds predominate.

The heaviest annual rainfall is 65 inches. It occurs near the borders of the Gulf States and along the Pacific seaboard in Washington and Oregon. The smallest annual rainfall is found in the Great Basin, it varies from 5 to 10 inches. East of the 100th meridian from Greenwich the average fall is 40 inches.

On the Atlantic coast rain is especially abundant during spring; on most of the Pacific coast, during winter.

The Weather Bureau was established for the observation of the meteorological conditions of the country.

There are four characteristic plant regions in the United States: the Forest, the Prairie, the Steppe, and the Pacific.

The forest region lies mainly east of the Mississippi; the characteristic trees are the pine, spruce, hemlock, fir, juniper, beech, maple, birch, alder, oak, and poplar.

The principal large animals of the United States are those which have been domesticated, as the horse, ox, cow, sheep, mule, goat, and dog.

Among wild animals are the black bear, panther, deer, grizzly bear, wolf, and manatee or sea-cow.

The principal agricultural productions are wheat, corn, rye, oats, barley, buckwheat, hay, hops, flax, tobacco, rice, cotton, and sugar.

The principal metals are gold, silver, platinum, iron, copper, zinc, lead, tin, mercury, chromium, nickel, cobalt, antimony, bismuth, and manganese.

Deposits of coal, rock-salt, marble, coal oil, and natural gas are found, and many varieties of durable building-stone.

Extensive peat-bogs occur in Massachusetts and Virginia.

The Territory of Alaska has an area of about 530,000 square miles and is nearly one-sixth that of the area of the rest of the domain of the United States.

The coast line of Alaska is very irregular, and has a length of at least 8000 miles.

Behring Sea on the west, and the Gulf of Alaska on the south, are the principal indentations of the coast. Norton Sound and Kuskovitch and Bristol Bays are among the most important of the smaller indentations.

The principal islands are St. Lawrence Island, Nunivak, the Aleutian Islands, Afognak, Kadiak, Baranoff, Chichagof, and Prince of Wales.

The northern portions of Alaska are low and flat, and are covered by tundras or frozen moor-lands. The rest of the country is generally mountainous, and is traversed by prolongations of the Pacific Mountain system of North America. Mts. St. Elias, Fairweather, and Crillon are the principal peaks.

The principal river of Alaska is the Yukon, which is some 2000 miles loug, and is one of the largest rivers of the North American Continent. The Kuskovim is the only other important river. The Yukon has a delta mouth—the Kuskovim, an estuary.

The climate of Alaska is cold and wet, though, under the combined influences of the Japan current, the rains, and the warm south-westerly winds, the climate is less severe than at corresponding latitudes in the interior, or on the Atlantic coast.

Dense growths of grasses abound during the brief summer. Forests of yellow cedar and spruce occur.

The chief animals are the polar and brown bears, the mink, black or silver fox, the moose, and the reindeer. The whale is found in the waters off the northern shores, and the walrus, the seal, and the sea-otter are sources of wealth by reason of their valuable furs. Salmon, halibut, cod, and herring, are the principal food-fish.

Deposits of coal, silver, gold, lead, and cinnabar occur in different parts of the country.

The inhabitants consist of various elements, the principal of which are the Esquimaux, the Indians, the Aleuts, the Creoles, and the people of the archipelagoes of the southern and south-eastern coast.

Sitka, on Baranoff Island, is the principal settlement.

REVIEW QUESTIONS.

State the geographical position of the United States.

Describe the peculiarities of its coast lines.

Name the principal indentations of the eastern coast. Of the western coast.

In what respect do the islands which lie north of Cape Cod differ from those which lie south of it?

What is the origin of the islands off the southern coast of Florida?

Describe the Pacific Mountain system. Locate the Great Plains. The Great Basin.

Describe the Appalachian Mountain system.

Name the great low plains of the United States.

Name the important rivers which drain directly into the Atlantic; name those which drain into the Atlantic through the Gulf of Mexico; name those which drain into the Pacific.

What system of inland drainage is found in the United States?

Describe the lake-systems of the United States.

In what mathematical zone is the United States situated? In what physical zones?

Between what isothermal lines does the United States extend?

Describe the general direction of the isotherm of 40° Fahr. Of 55° Fahr. Of 60° Fahr.

What difference exists between the climate of the eastern and western coasts? What are the causes of this difference?

Has the climate of the United States undergone any decided change during the last hundred years?

In what wind zone does the United States lie?

In what parts of the country does the heaviest annual rainfall occur? The smallest annual rainfall?

What is the rainfall of the upper Mississippi Valley? Of the lower Mississippi?

At what season of the year do the heaviest rains occur on the Atlantic coast? On the Pacific coast?

For what was the Weather Bureau established?

What are tornadoes?

Under what four characteristic plant regions may the vegetation of the United States be arranged?

Describe the location of each of these regions.

Name the principal forest trees of the United States.

Name the principal domesticated and wild animals of the United States.

Enumerate the principal agricultural productions.

Name the principal corn-producing States. The principal wheat-producing States.

Name the principal cotton-producing States. The principal rice-producing States. The principal sugar-producing States.

What valuable metals are found in the United States?

What other valuable mineral substances occur?

What are the limits of the Territory of Alaska? State its boundaries. What is its area?

What sum was paid for Alaska by the United States Government?

Name the principal indentations of the coast of Alaska. What is the extent of its coast line?

Name the principal islands of the western coast. Of the southern coast.

Describe the surface structure of Alaska. To what general system of mountains do its elevations belong? Name some of the principal peaks. Are any of them volcanic?

Describe the river-system of the Yukon. Where is the Kuskovim River? Which of these rivers has a delta mouth? Which has an estuary?

What is the general climate of Alaska? How does the climate compare with that of corresponding latitudes in the interior of the country or on the Atlantic coast? Why is this?

Describe the vegetation of Alaska. What are the principal trees?

Name the principal food-fish of Alaska. Name the principal fur-bearing animals. What other large animals are found in the country?

Which is the principal settlement? Name some of the different people who inhabit Alaska.

MAP QUESTIONS.

Describe from the Physical Map of the United States the surface structure of the country, giving the relative position of the High Lands and Low Lands.

Describe the Pacific Mountain System.

Describe the Appalachian Mountain System.

Locate the following: the Black Hills; the Wahsatch Mountains; the Sierra Madre; San Louis Park; Pike's Peak; Long's Peak; Fremont's Peak.

Describe the drainage of the Great Lakes.

Name the principal rivers which empty into the Atlantic. Into the Gulf of Mexico. Into the Pacific.

Name the principal tributaries of the Mississippi.

Where are the Santa Barbara Islands? The Bahama Islands? Vancouver's Island?

Trace on the map the isothermal line of 45°.

What is the cause of the southward deflection of the isothermal lines in the western part of the United States?

Prove from the isotherms that the climate of the northern half of the Atlantic coast is colder than the southern half.

In what portions of the United States is the lowest mean annual temperature found? The highest?

Name the swamps and sounds of the Atlantic seaboard whose formation is to be traced to fluvio-marine deposits.

What swamp is due to coral formations?

GENERAL SYLLABUS.

Physical Geography treats of the distribution of the land, water, air, animals, and plants of the earth.

The earth moves through empty space around the sun. It is kept in motion in its orbit by its inertia and the attraction of the sun.

The rotundity of the earth is proved—1. By the appearance of approaching or receding objects; 2. By the circular shape of the horizon; 3. By the shape of the earth's shadow; 4. By the great circle of illumination; 5. By actual measurement.

Exact geographical position is determined by reference to certain imaginary lines called parallels and meridians.

Representations of the whole or of parts of the earth's surface are made by means of maps.

Maps are drawn on different projections: the Equatorial, the Polar, and Mercator's projection are in the most general use.

The length of daylight in either hemisphere depends on the extent to which that hemisphere is inclined towards the sun; the longest day in the northern hemisphere occurring June 21st, when the sun is vertical over the Tropic of Cancer.

The change of seasons is occasioned by the revolution of the earth, together with the inclination of the earth's axis at an angle of 66° 33′ to the plane of its orbit, and the constant parallelism of the axis with any former position.

The Torrid Zone is the hottest part of the earth, because, at one time or another throughout the year, every part of its surface receives the vertical rays of the sun.

The following different opinions are held concerning the condition of the interior of the earth:

(1.) That the earth has a solid centre and crust, with a heated layer between.

(2.) That the crust only is solid, and the remainder sufficiently heated to be in a fused or pasty condition.

(3.) That the earth is solid throughout, but highly heated in the interior.

The proofs of the present highly-heated condition of the interior of the earth are as follows:

1. In all parts of the earth, the deeper we penetrate the crust, the higher the temperature becomes; that is to say, the entire interior is heated.

2. The presence of volcanoes, which, in all latitudes, eject melted rock from the inside of the earth; that is to say, the entire interior is filled with matter sufficiently hot to melt rock at ordinary pressures.

3. The occurrence of earthquake shocks in all parts of the earth.

The original fluidity of the earth is rendered probable by the following circumstances:

(1.) By the spherical shape of the earth.

(2.) The crystalline rocks, or those formed in the presence of great heat, underlying all others.

(3.) The warmer climate of the earth during the geological past.

Volcanoes eject from the interior of the earth—1. Melted rock or lava; 2. Showers of ashes or cinders; 3. Vapors or gases.

These materials are brought up from great depths into the volcanic mountain by the force caused by a contracting globe. They may escape from the crater—1. By the pressure of highly-heated vapors; 2. By the pressure exerted by a column of liquid lava.

All volcanoes are found near the coasts of the continents, or on islands.

The movements of the earth's crust produced by earthquake shocks are—1. A wave-like motion around the centre of disturbance; 2. An upward motion; 3. A rotary motion.

The following facts have been discovered as regards earthquakes:

(1.) Their place of origin is not very deep seated.

(2.) The area of disturbance increases with the energy of the shock and the depth of its origin.

(3.) The shape of its origin is that of a line and not that of a point.

(4.) The shape of the area of disturbance varies with the elasticity of the materials through which the shock moves.

(5.) The earthquake motion travels as spherical waves, which move outward in all directions from their point of origin.

The most violent earthquake shocks continue but for a short time.

Earthquakes are generally caused by the strain produced by the contraction of the crust.

Earthquake shocks are of more frequent occurrence—1. In winter than in summer; 2. At night than during the day; 3. During the new and full moon, than during any other phase.

Earthquake shocks may occur in any part of the world, but are of most frequent occurrence in the neighborhood of volcanoes.

Rocks may be divided, according to their *origin*, into three classes: 1. Igneous; 2. Aqueous; 3. Metamorphic.

They may be divided according to their *condition*, into—1. Stratified; 2. Unstratified.

Unstratified rocks are either igneous or metamorphic.

Rocks which contain organic remains are said to be fossiliferous; if destitute of these remains, non-fossiliferous.

Stratified rocks are sometimes called fragmental. Unstratified rocks are sometimes called fragmental. Aqueous rocks are sometimes called sedimentary.

During the geological past extensive changes occurred in the land and water surface of the earth, and in the plants and animals inhabiting it.

The changes now occurring in the earth's crust are caused—1. By the winds; 2. By the moisture of the atmosphere; 3. By the action of running water; 4. By the agency of man; 5. By the action of the heated interior.

Of the 197,000,000 square miles of the earth's surface, 144,000,000 square miles are covered by water, and 53,000,000 by land. The proportion between the land and water is very nearly as the square of three is to the square of five.

The continents extend farther to the north than to the south; they are crowded together near the north pole. Their southern projections are separated from each other by extensive oceans.

Nearly all the land masses are collected in one hemisphere, and a large part of the water in another.

There are two great systems of trends or lines of direction, along which the shores of the continents, the mountain-ranges, the oceanic basins, and the island chains extend.

The main prolongation of the eastern continent is in the direction of the north-eastern trend; the western, in that of the north-western trend.

The coast lines of the northern continents are very irregular, the shores being deeply indented with gulfs and bays, while those of the southern continents are comparatively simple and unbroken.

Of the 53,000,000 square miles of the land, 3,000,000, or about one-seventeenth, is composed of islands.

Islands are either continental or oceanic.

Continental islands are detached portions of the neighboring continents.

Oceanic islands are the summits of submarine mountain-chains. They are either high or low: the high oceanic islands are generally of volcanic formation; the low islands are of coral formation. Mangrove islands occur off the coasts of Florida.

There are four varieties of coral formations: 1. Fringing reefs; 2. Barrier reefs; 3. Encircling reefs; 4. Atolls.

A peculiar variety of coral reef occurs off the coasts of Florida.

The subsidence of the ocean's bed is proved—1. By the exclusive occurrence of volcanoes on the shores of the continents or on islands; 2. By the occurrence of atolls or coral islands; 3. By the general direction of the continental island chains.

The earth's surface is composed of high lands and low lands. The dividing line is 1000 feet above the level of the sea.

High lands are either mountainous or plateaus.

Low lands are either hills or plains.

About one-half of the land surface of the earth is occupied by plains.

Plains are 1. Undulating; 2. Marine; 3. Alluvial.

Mountains were formed by the contraction of the earth's crust, producing a lateral pressure on extended, thick deposits of sedimentary rocks. Slaty cleavage was caused by this lateral pressure.

The following peculiarities are noticeable in the relief forms of the continents:

1. The continents have, in general, high borders and a low interior.

2. The highest border lies nearest the deepest ocean; hence, the culminating point, or the highest point of land, lies out of the centre of the continent.

3. The greatest prolongation of a continent is always that of its predominant mountain-system.

4. The prevailing trends of the mountain masses are the same as those of the coast lines, and are, in general, either north-east or north-west.

Water acquires its maximum density at about the temperature of 39.2° Fahr.

Water requires more heat to warm it, and gives out more on cooling, than any other common substance.

During the constant washings to which the continents are subjected by the rains, their surfaces are cleansed of the decaying animal and vegetable matters which cover them.

The drainage of the land is of two kinds: subterranean and surface drainage.

Surface drainage is either oceanic or inland.

According to the size of their reservoirs, springs are either constant or temporary; according to the depth of the reservoirs, they are either cold or hot; according to the nature of the mineral substances lining their reservoirs, they become charged with various mineral substances; if their reservoirs discharge through a siphon-shaped tube, they are periodical; if their reservoirs are formed of concave layers, they are called artesian springs.

The quantity of water discharged by a river depends—1. On the size of its basin. 2. On the amount of its rainfall. 3. On the climate of its basin, a dry, hot air diminishing the quantity by evaporation. 4. On the nature of its bed or channel, whether leaky or not. 5. On the features of its basin, whether wooded or open.

The material eroded by a river is deposited—1. In the channel of the river. 2. On the alluvial flats or flood-grounds. 3. At the mouth. 4. Along the coast near the mouth.

In the upper courses of rivers erosion occurs mainly on the bottom of the channel; in the lower courses, at the sides.

The Atlantic and Arctic Oceans receive the waters of nearly all the large river systems of the world.

Lakes connected with the system of oceanic drainage are generally fresh; those connected with the inland drainage are generally salt.

The bed of the ocean is less diversified than the surface of the land.

The greatest depth of the ocean is probably greater than the greatest elevation of the land.

The articulation of land and water assumes four distinct forms,—inland seas, border seas, gulfs and bays, and fiords.

Inland seas characterize the Atlantic; border seas, the Pacific; gulfs and bays, the Indian; fiords, the Atlantic and Pacific.

A deposit of fine calcareous mud or ooze, formed of the hard parts of minute animalculæ, occurs over extended areas of the floor of the ocean.

Tides are caused by the attraction of the sun and moon; spring tides by their combined attractions; neap tides, by their opposite attractions.

Constant ocean currents are occasioned by the heat of the sun and the rotation of the earth.

The vertical rays of the sun are warmer than the oblique rays—1. Because they have a less depth of air to pass through. 2. Because they are spread over a smaller area. 3. Because, striking the surface more directly, they produce greater heat.

Continual summer characterizes the tropics; summer and winter of nearly equal duration, the temperate zones; and short, hot summers, followed by long, intensely cold winters, the frigid zones.

The irregular distribution of heat over the earth is caused—1. By the irregularities of the surface. 2. By peculiarities in the distribution of the land- and water-areas. 3. By the influence of the winds and ocean currents. 4. By the nature of the surface.

Winds are caused by the disturbance of the equilibrium of the atmosphere by heat.

The general motion of the surface winds is towards an area of greatest heat; of the upper currents, towards an area of least heat.

The general atmospheric circulation is from the equator to the poles, and from the poles to the equator.

In storms, the wind has a rotary motion around an area of low barometer, which, at the same time, progresses along the surface.

In the northern hemisphere, the rotary motion is in an opposite direction to the hands of a clock; in the southern hemisphere, in the same direction as the hands of a clock.

Moisture may be precipitated from the air in the form of dew, mist, fog, cloud, rain, hail, sleet, or snow.

In order that any form of precipitation may occur, the air must be reduced below the temperature of its dew-point.

Glaciers are immense masses of ice and snow, which move with extreme slowness down the higher valleys of mountain-ranges. They resemble rivers in that they receive through the drainage of their basins, the solid material which flows into them.

The snow line is the distance above the sea where the snow remains throughout the year. The height of its lower level above the sea depends (1.) On the amount of the snowfall. (2.) On the temperature of the valley. (3.) On the inclination of the slope.

The unit of electric potential is called a volt; the unit of current an ampère; the unit of resistance an ohm. Comparing the flow of electricity to a current of water in a pipe, the volt corresponds to the pressure causing the flow, the ohm to the resistance, or friction, opposing it, and the ampère to the quantity of flow per second.

The principal electrical phenomena of the atmosphere are thunder and lightning, St. Elmo's fire, and the aurora.

The principal optical phenomena are the rainbow, the mirage, halos, and coronæ.

The earth acts like a huge magnet. Its magnetism is probably due to the circulation around it of electrical currents, generated by the sun's heat.

The true basis for the distribution of vegetation is the distribution of the light, heat, and moisture, upon which its existence mainly depends.

The variety and luxuriance of vegetation decrease as we pass from the equator to the poles, or from the base of a mountain to the summit.

The principal food-plants of the tropical regions are rice, bananas, plantains, dates, cocoa-nuts, cassava, bread-fruit, sago, and yams.

Coffee, tea, cocoa, pepper, cloves, nutmegs, and vanilla are also products of the tropics.

The principal food-plants of the temperate zones are barley, rye, wheat, oats, maize or Indian corn, buckwheat, and the potato.

Animals are restricted, by conditions of food and climate, to certain regions of the earth.

They are dependent for their continued existence upon plants, the distribution of which therefore forms an excellent basis for the distribution of animals.

With a few exceptions, animals possess but little power of becoming acclimated, or living in a climate differing greatly from that in which they were created.

The grassy meadows and prairies in North America cause the fauna of the continent to be characterized by a preponderance of plant-eating mammals. Its extensive lake- and river-systems harbor a great number and variety of waterfowl.

South America is characterized by the predominance of its reptiles and insects. Birds are also numerous.

Asia is the home of domesticated animals.

Australia is the home of the marsupials.

The luxuriant vegetation of the south of Africa sustains some of the largest of the mammalia, such as the elephant, rhinoceros, hippopotamus, and giraffe.

The entire human family has descended from a single pair or species.

The primary races of men are the Caucasian, the Mongolian, and the Negro.

The secondary races are the Malay, the American, and the Australian.

The coast line of the United States is comparatively simple and unbroken.

The predominant mountains are in the west; the secondary mountains are in the east.

The great low plains of the United States are the Atlantic coast plain and the plain of the Mississippi Valley.

The United States lies in the physical north temperate and the physical torrid zone.

The climate of the northern half of the Atlantic coast is much colder than that of the northern half of the Pacific.

The United States lies in the zone of the variable winds.

The heaviest rainfall is on the Pacific coast and near the borders of the Gulf States.

There are four distinct plant regions: the forest, the prairie, the steppe, and the Pacific.

The Territory of Alaska occupies an area of 550,000 square miles.

The Territory of Alaska is mainly mountainous. The shore lands of the Arctic are frozen moor-lands like the tundras of Asia.

The Yukon and Kuskovim are the principal rivers.

Myriads of salmon visit the rivers during the breeding season.

Valuable food-fish are found in the waters off the coasts.

Numerous fur-bearing animals are found in Alaska.

GENERAL REVIEW QUESTIONS.

Mathematical Geography.

What is the earth's position in the solar system?

How much larger is the sun than the earth?

Of what use are latitude and longitude?

Distinguish between a map of the earth on a Mercator's projection, and maps on equatorial and polar and conical projections.

Explain the cause of the change of day and night.

Explain the causes of the change of seasons.

The Land.

Enumerate the proofs of the present heated condition of the interior of the earth.

What is the theory for the exclusive occurrence of volcanoes near the borders of the ocean?

Why is it unnecessary to consider the interior of the earth as in a fluid condition like that of the lava ejected from volcanoes?

Name the principal regions of active volcanoes.

What facts have been discovered respecting earthquake shocks? Why should the shocks occur more frequently at night than during the day, or during winter than summer?

Into what two classes may unstratified rocks be divided?

Explain the origin of coal.

Enumerate some of the changes which are now taking place in the crust of the earth.

What are the relative land- and water-areas of the earth?

Describe the land hemisphere. The water hemisphere.

What do you understand by lines of trend?

Which of the continents contains, in proportion to its area, the greatest length of coast line? Which the least?

Distinguish between continental and oceanic islands; between coral and volcanic islands.

Why does the presence of an atoll in any part of the ocean prove the subsidence of its bed at that point? Explain the nature of the coral formations off the southern coast of Florida.

What do you understand by the forms of relief of the land?

Distinguish between a mountain and a hill. A plateau and a plain.

What peculiarities are noticeable in the general relief forms of the continents?

Which of the continents resemble each other in the general arrangement of their relief forms? In what respect do they all resemble one another?

The Water.

Enumerate the principal uses of water in the economy of the earth.

What effect has the high specific heat of water on the climate of maritime countries?

What is the cause of the heat developed during the condensation of a mass of vapor?

Distinguish between subterranean and surface drainage.

Explain in general the origin of springs.

Into what different classes may springs be divided according to the size of their reservoirs? According to the shape? The location? The shape of the outlet tube?

Define calcareous, silicious, sulphurous, chalybeate, brine, and acidulous springs.

Define river-system, basin, water-shed, source, channel, and mouth.

Explain the origin of waterfalls.

By what are the inundations of rivers caused?

What is silt? In what different parts of a river-system may silt be deposited? Define fluvio-marine formations.

In what respects do the drainage-systems of North and South America resemble each other?

In what respects do the river-systems of Africa resemble those of the Americas?

Why are the waters of lakes with no outlets generally salt?

Name the great fresh-water lake-systems of the world.

State the composition of ocean-water. What is its density? Its boiling-point? Its color?

How do the five oceans compare with one another in area?

Distinguish between inland seas, border seas, and gulfs and bays, and fiords.

What facts are known respecting the shape of the bed of the Atlantic Ocean? Of the Indian Ocean? Explain the origin of the ooze-deposits on the ocean's beds.

By what are waves caused? Upon what does their height depend?

How are tides caused?

Distinguish between ebb, flood, spring, and neap tides.

Where does the parent tidal wave originate?

In what part of the ocean are tides the highest? Why?

What are the main causes of constant oceanic currents?

In what respects do the currents in the three central oceans resemble one another?

The Atmosphere.

What is the composition of the atmosphere?

By what instrument is the pressure of the atmosphere measured?

What proof have we that the greater weight of the atmosphere lies within a few miles of the earth's surface?

Define climate. Enumerate the circumstances which influence the climate of a country.

Why are the vertical rays of the sun warmer than the oblique rays?

In what different ways does the atmosphere receive its heat from the sun?

Explain the origin of winds.

Why should the general direction of the atmospheric circulation be between the equator and the poles?

Name the different wind zones of the earth.

What is the origin of land and sea breezes?

What resemblance do land and sea breezes bear to monsoons?

Describe some of the peculiarities of cyclones.

What facts have been discovered in regard to the great storms of the United States?

Enumerate the circumstances upon which the rapidity of evaporation depends.

State the general law for the occurrence of precipitations.

Under what circumstances will a heavy deposition of dew occur?

Name the primary forms of clouds. The secondary forms.

Explain the peculiarities of the rainfall in each of the wind zones.

Why is the rainfall on mountains heavier than that on plains?

Define snow line. On what three circumstances does the height of the snow line depend?

Describe the formation of a glacier.

Enumerate the principal electrical and optical phenomena of the atmosphere.

What is the probable cause of the earth's magnetism?

Define volt, ohm, ampère. What analogies exist between the flow of water in a pipe and an electric current?

Organic Life.

Why should the distribution of light, heat, and moisture form the best basis for the distribution of vegetation?

Define flora. Distinguish between the horizontal and the vertical distribution of vegetation.

State the limits of each of the horizontal zones of vegetation.

What is the characteristic feature of the flora of each of these zones?

State the conditions requisite for the existence of forests; of prairies; of steppes; of deserts.

Enumerate the principal cultivated plants of the torrid, temperate, and polar zones.

Define fauna.

Upon what is the existence of animal life dependent?

What is the cause of the change noticed in the fauna in passing from the equator to the poles, or from the base to the summit of a high tropical mountain?

Enumerate the characteristic tropical fauna; the temperate fauna; the arctic fauna.

What is the characteristic peculiarity of the fauna of each of the continents?

Enumerate the proofs of the probable unity of the human race.

Name the portions of the world inhabited by each of the primary and secondary races.

Physical Features of the United States.

What is the area of the United States, exclusive of Alaska?

Describe the surface structure of the United States.

Describe the drainage-systems of the United States.

What are the causes of the difference in the temperature of the eastern and western coasts?

Between what extremes of mean annual temperature are the United States included?

In what wind zone is the United States situated?

Name the four principal regions of vegetation.

Enumerate the chief agricultural productions of the country.

What large animals are found in the United States?

Name the chief mineral productions.

What is the area of Alaska?

What are the principal indentations of its coast?

Name the principal islands of Alaska.

Describe the river-system of the Yukon.

Name the principal trees of Alaska. Name its principal fur-bearing animals. Its principal food-fishes.

GENERAL MAP QUESTIONS.

Volcanoes and Earthquakes.

Describe the volcanic districts of the Pacific Ocean.

In what portions of these districts are volcanoes most numerous?

Describe the volcanic districts of the Indian Ocean.

In what direction do most of the lines of fracture in this ocean extend?

Describe the volcanic districts of the Atlantic.

Where are submarine eruptions most numerous in this ocean?

Describe the earthquake district of the Mediterranean Sea and Central Asia.

What other portions of the world are especially liable to earthquake shocks?

Name the parts of the world shaken by the great earthquake of Lisbon, in 1755.

Oceanic Areas and River-Systems.

What two oceans receive the drainage of the greatest areas of the continents?

State, from a careful inspection of the direction in which the principal river-systems flow, the direction of inclination of the principal slopes of the continents.

Observe that in most of the continents there is a long gentle slope and a short abrupt slope; state the general direction of each of these slopes.

Locate the principal systems of inland drainage in each of the continents.

Name the principal lakes and rivers belonging to the larger of these systems.

Describe in general the river-systems of the Atlantic, or the rivers draining into the Atlantic. Describe the river-systems of the Pacific. Of the Indian. Of the Arctic.

Enumerate the five largest rivers belonging to each of these river-systems.

Name the principal rivers of the world which have delta mouths.

What are the land and water boundaries of each of the five oceans?

Ocean Currents.

What is the general direction of the equatorial ocean currents? Explain the cause of this general direction. What exception can you find to it?

What is the general direction of the Arctic currents? Of the Antarctic currents?

What are the causes of these general directions?

Describe the principal currents of the Atlantic; of the Pacific; of the Indian Ocean.

Locate the principal grassy seas.

Explain the cause of these seas.

Name the principal warm ocean currents; the principal cold ocean currents.

Name some cold currents which powerfully affect the climate of different parts of the earth? Name some warm currents which powerfully affect the climate.

In what respects do the general directions of the currents in each of the central oceans resemble one another?

Name the points of resemblance between the Gulf Stream and the Japan Current.

Isothermal Lines and Physical Zones.

Point out the most striking deviations in the directions of the isothermal lines from the parallels of latitude.

Explain in each case the main cause of these deviations.

In what part of the world do the isothermal lines coincide most nearly with the parallels?

Trace on the map the isothermal line of 79° Fahr. Of 32° Fahr. Of 40° Fahr.

In what parts of the world is the highest temperature found during the month of July?

What is the temperature of the greatest cold of January? Where is it found?

What is the mean temperature of London for January? For July? What other large cities have nearly the same mean July or January temperature as London?

What is the mean temperature of Bombay for January? For July? What other large cities have nearly the same mean July or January temperature as Bombay?

Point out the northern limit of drift ice. The southern limit.

Why is it advantageous for a vessel sailing from England or America viâ the Cape of Good Hope to maintain an easterly direction both going and returning?

Describe the boundaries of the physical torrid, temperate, and frigid zones.

Name the principal countries which lie wholly or in part in each of these zones.

Winds, Rain, and Ocean-Routes.

State the boundaries of each of the wind zones.

What is the general direction of the wind in each of these zones?

Name the principal monsoon regions of the world.

Enumerate the principal mountain and desert winds.

What is the direction of the rotation of the wind in the cyclonic storms of the northern hemisphere? Of the southern hemisphere?

Name the principal storm-regions of the world.

Describe the characteristic rainfall in each of the principal wind zones.

What would be the general route of a vessel in sailing from America to Europe, and back again? From Europe to San Francisco?

What two sailing routes are there from Europe to Australia or India?

Vegetation.

Give the boundaries of each of the plant zones.

State the countries or portions of countries which lie in each of these zones.

Name some of the useful plants of each of these zones.

Point out on the map the northern limit of trees. The southern limit.

Name the portions of the world from which valuable timber is obtained.

What are the principal tea- and coffee-growing countries of the world?

Where are the principal forests?

Animals.

What limits are assumed as the boundaries of the tropical, temperate, and arctic fauna?

Name the principal tropical, temperate, and arctic fauna?

What domesticated animals are found in the tropical and temperate zones?

Trace on the map the northern limit of the camel and of the reindeer; of monkeys. The southern limit of the camel; of monkeys; of the polar bear, and of the elephant and rhinoceros.

In what parts of the world are the whale, seal, and walrus found?

Describe the limits of the grizzly bear. Of the musk-ox.

What are the characteristic animals of the New World? Of the Old World?

State the characteristic fauna of North America. Of South America. Of Europe, Asia, Africa, and Australia.

The Races of Men.

Trace on the map the northern and southern limits of permanent habitation.

Name all the countries of the world inhabited by the Caucasian race.

In what parts of the world are the Caucasians mixed with other races?

Name the different countries of the world inhabited by the Mongolian race.

Name some of the different peoples belonging to this race.

What parts of the world are peopled by the Ethiopian, or Negro race?

Name some of the different tribes belonging to this race.

Name the different countries of the world inhabited by the secondary races of men?

Give the names of the principal tribes of each of the secondary races.

What different races of men inhabit North America? South America? Europe? Asia? Africa? Australia?

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Physical Map of the United States.

Describe from the map the forms of relief of the United States.

Name the principal mountain-ranges belonging to the predominant and secondary mountain-systems.

Describe the drainage-systems of the United States.

What large lake-system is situated in the north-eastern part of the United States?

Trace on the map the general directions of the principal isothermal lines, showing the hottest and coldest portions of the country.

Name the principal islands which lie near the coasts of the United States.

Name the fluvio-marine formations of the eastern coast.

PRONOUNCING VOCABULARY.

SOUNDS OF THE LETTERS.

Vowels.

Fåte, får, fåll, fåt, ạ (obscure), as in organ, oval; ah, intermediate between å and å, as in al-ạ-bah′-mạ; åå or å long; mê, mĕt, ẹ, as in berth, ravel; pine or pīne, pin, ị, as in firm, evil; nô, nŏt, ọ, as in sermon, harbor; oo, as in moon; ŏŏ, as in good; ŏw, as in now; ū, as in tube; ŭ, as in tub; ü, the French eu, nearly like u in tub, or fur; y and ey, at end of unaccented syllable, like e in me; ai and ay, like a in fate; au and aw, as a in fall; ĕĕ, as i in pit; ŏw or au, as now or our.

Consonants.

Th as in thin; TH, as in this; D, as TH, in this; G and K, sound of the German ch, somewhat like our h, strongly aspirated. ñ indicates a blending of the sounds of n and y; Ī, a blending of l and y; M and N and N^G, nasal, like our ng; R, like rr in terror; ŵ, like our v. Pronounce all other letters as in English.

The primary or *principal accent is marked thus* (′); the secondary, thus (‵).

In determining the correct pronunciation of a word, *first* sound the separate syllables *distinctly*, repeating the process several times; *afterward* pronounce the whole word smoothly and continuously, being careful to mark the accents; *e.g.* Nevada, nå-vå′-då, nay-vah′-dah; Apache, å-på′-chå, ah-pah′-chay; Canada, kån′-ạ-dạ, kan′-ŭh-dŭh.

A.

Abyssinia, ab-is-sin′-e-ạ.
Aconcagua, å-kon-kå′-gwå.
Adelsberg, å′-dẹls-bĕrg‵.
Adriatic, ad‵-re-at′-ic.
Afghanistan, åf-gån‵-is-tån′.
Agulhas, å-gool′-yås.
Alabama, al-ạ-bah′-mạ.
Alaska, ål-ås′-kå.
Albemarle, al-be-marl′.
Aleutian, ạ-lu′-she-ạn.
Algiers, ål-jeerz′.
Alleghanies, al-le-gạ′-nees.
Altamaha, ål-tạ-mạ-haw′.
Amazon, am′-ạ-zọn.
Amboyna, åm-boi′-nå.
Amoo, å-moo′.
Amoor, å-moor′.
Anahuac, ån-å-wåck′.
Anatolia, ån-ạ-tō′-le-ạ.
Anticosti, an-te-kos′-tee.
Antilles, ån‵-teel′.
Antisana, ån-te-så′-nå.
Appalachicola, ap‵-pạ-lah‵-che-ko′-lạ.
Apennines, ap′-en-nīnz‵.
Appalachian, ap-pạ-lå′-che-ạn.
Apsheron, åp-shå-ron′.
Ararat, år′-ạ-rat‵.
Archangel, ark-ån′-jẹl.
Arequipa, å-rå-kee′-på.
Arizona, ar‵-i-zo′-nạ.
Arkansas, ar-kan′-sas.
Armenia, ar-mee′-ne-ạ.
Arveiron, åR‵-vī-ron′.
Asia, å′-she-ạ, not å′-zhe-ạ.
Atacama, å-tå-kå′-må.
Athabasca, ạth′-ạ-bạs′-kạ.
Auckland, åwk′-lạnd.
Auvergne, ō‵-vairñ′.
Azores, az′-ōrs, or az-orz′.
Azov, åz′-ov‵, or å-zov′.

B.

Babylonian, bab-e-lo′-ne-ạn.
Bahamas, bạ-hå′-mạ.
Baikal, bi′-kål.
Baku, bå‵-koo′.
Balkan, bål-kån′.
Balkash, bål‵-kåsh′.
Baltimore, bawl′-te-more, or bawlt′-ẹ-mọr.
Banda, bån′-då.
Barbadoes, bar-bå′-dọz.
Batavia, bạ-tå′-ve-ạ.
Baton Rouge, bat′-ọn-roozh.
Bedouins, bed′-oo-inz.
Beled-el-Jerid, bĕl′-ed-el-jer-eed′.
Beloochistan, bel-oo‵-chis-tån′.
Belor, or **Bolor,** bô-lor′.
Bengal, bĕn-gawl′.
Berlin, bẹr′-lin.
Bermudas, bẹr-moo′-dạz.
Bernina, bĕr-nee′-nå.
Bohemian, bo-hee′-me-ạn.
Bolivia, bo-liv′-e-ạ. (Spanish pron., bo-lee′-ve-å.)
Bombay, bom-bå′.
Boothia Felix, boo′-the-å fe′-liks.
Bourbon, bŭr′-bọn.
Brahmapootra, brah‵-mạ-poo′-trạ.
Brazos, brah′-zọs.
Buenos Ayres, bo′-nọs å′-riz, or bo′-nọs airz. (Spanish pron., bwå′-noce ī′-rês.)

C.

Cairo, kī′-ro.
Calabria, kạ-lå′-bre-ạ.
Calcutta, kal-kŭt′-tạ.
Cambodia, kam-bô′-de-ạ.

Cambridge, kāme-brij′.
Cameroons, cam-er-oons′.
Cantabrian, kăn-tā′-bre-ạn.
Canton, kan-ton′.
Cape Verde, vẹrd′.
Caribbean, kar‵-rib-bee′-an.
Carpathian, kar-pā′-the-ạn.
Castile, kăs-teel′.
Cauca, kŏw′-kä.
Caucasus, kaw′-kä-sŭs.
Cayenne, kä-yĕnn′, or kī‵-ĕnn′.
Celebes, sĕl′-e-bes.
Ceram, sĕ-răm′.
Cevennes, sā‵-vĕnn′.
Ceylon, see′-lon, or sil-ōn′.
Chagos, chä′-gōs.
Chamouni, shä‵-moo-nee′ (or Chamonix, shä‵-mo-nee′).
Champlain, sham-plāne′.
Charleston, charlz′-tọn.
Chelyuskin, chel-yŭs′-kịn.
Chicago, she-kaw′-go.
Chili, chil′-lee.
Colima, ko-lee′-mä.
Colorado, kol-o-rah′-do.
Como, ko′-mo.
Comorin, com′-ō-rin.
Comoro, kom′-o-ro.
Congo, kong′-go.
Constance, kon-stănts′.
Cosiguina, ko-se-ghee′-nä.

D.

Dakota, dạ-kō′-tạ.
Danube, dăn′-ūbe.
Deccan, dĕk′-kạn.
Demavend, dĕm‵-ä-vĕnd′.
Detroit, de-troit′.
Dhawalaghire, dạ-wŏl‵-ạ-ghĕr′-ree.
Dinaric, de-năr′-ic.
Dnieper, nee′-pr.
Dniester, nees′-tẹr.
Dra, drä.
Duna, dū′-nä.
Dwina, dwī′-nạ, or hwee′-nä.

E.

Ecuador, ĕk-wä-dōr′.
Edgecumbe, ĕj′-kum.
Edinburgh, ĕd′-in-bŭr-rŭh.
Elbe, ĕlb. (Ger. pron., ĕl′-beh.)
Elbruz, ĕl‵-brooz′.
Elton, ĕl‵-ton′.
Euphrates, u-frā′-tēz.
Everest, ĕv′-ĕr-ĕst.
Eyre, air.

F.

Falkland, fawk′-lạnd.
Fayal, fī-äl′.
Feejee, fee′-jee.
Fezzan, fĕz‵-zăn′.
Finsteraarhorn, fins′-ter-äär-horn.
Flores, flo′-rĕs.
Formosa, for-mo′-sä.
Fusi Yama, fū-si-yä-mä′.

G.

Gairdner, gard′-ner.
Gallapagos, gä-lä′-pä-goce.
Ganges, gan′-gēz.
Gardafui, gar‵-dạ-fwee′.
Garonne, gä‵-ronn′.
Gaudaloupe, gwä-dä-loo′-pä.
Ghauts, gawts.
Gila, heel′-ä.
Gilolo, je-lo′-lo.
Greenwich, grin′-idge.
Grenada, grẹn-ā′-dạ.
Grenelle, grẹh‵-nĕll′.
Guadeloupe, gaw‵-da-loop′, or gä-dẹh-loop′.
Guadiana, gwä-de-ä′-nä.
Guardafui, gwar-dä-fwee′.
Guiana, ghe-ä′-nä.
Guinea, ghin′-nee.

H.

Halle, häl′-lẹh.
Hartz, harts.
Havana, hạ-van′-ạ.
Hawaii, hä-wī′-ee.
Hayti, hā′-tee.
Hecla, hĕk′-lä.
Himalaya, him-ä-lā′-yạ, or him-ä′-lạ-yạ.
Hindoo-Koosh, hin′-dōō-kōōsh.
Hindostan, hin‵-dọ-stăn′.
Hoang-Ho, ho-ang‵-hō′, nearly whang‵-ho′.
Hoogly, hoog′-lee.
Humber, hŭm′-bẹr.
Hungarian, hung-ga′-re-an.

I.

Iberian, ī-bee′-re-ạn.
Ilaman, or Illimani, eel‵-yä-mä′-ne.
Illinois, il‵-lin-oi′.
Indiana, in‵-de-an′-ạ, or in-de-ah′-nạ.
Indianapolis, in-de-an-ap′-ọ-lis.
Iowa, i′-o-wạ.
Irrawaddy, ir‵-rạ-wăd′-dē.

J.

Jamaica, jạ-mā′-kạ.
Jan Mayen, yăn-mī′-ẹn.
Japan, jä-păn′.
Java, jä′-vạ, or jah′-va.
Jorullo, ho-rool′-yo, or ho-roo′-yo.

K.

Kaffa, kăf′-fä.
Kalahari, käl-a-hä′-rē.
Kamtchatka, kăm-chăt′-kạ.
Karakorum, kä‵-rä-ko′-rŭm.
Kenia, kē′-ni-ạ.
Kentucky, kĕn-tŭk′-ee.
Kerguelen, kẹrg′-ẹ-lẹn.
Keweenaw, ke-wee′-naw.
Kilauea, kē‵-lō′-ä-ä.
Kilimandjaro, kil‵-e-măn‵jä-rō′.
Kinghan, kin-găn′.
Kiolen, ky-ō′-lẹn, or chō′-lẹn.
Kodiak, ko′-de-ăk.
Kong, kŏng.
Kosciusko, kos-se-ŭs′-ko.
Kuen-lun, kwĕn‵-loon′.
Kunchinjunga, koon-chin-jung′-gä.
Kurile, koo′-ril.

L.

Laccadive, lăk′-ka-dīv‵.
Ladoga, lä′-do-gä.
Ladrones, lăd-rōnz′.
Lapland, lap′-lạnd.
La Puebla, lä pwĕb′-lä.
Lauterbrunnen, lŏw′-ter-brŏŏn‵-nẹn.
Lima, lee′-mä.
Limpopo, lim-pō′-pō.
Llanos, l′yä′-nōs.
Llullayacu, l′yoo-l′yī-l′yä′-kō.
Loffoden, lof-fo′-dẹn.
Loire, lwär.
Lombardy, lom′-bạr-de.
Loo Choo, loo‵-chew′.
Louisiana, loo-ee-ze-ah′-nạ.
Louisville, loo′-is-vil, or loo′-e-vil.
Lowell, lō′-el.
Lupata, lu-pä′-tä.

M.

Macao, mä-kŏw′, or mä-kä-o.
Mackenzie, mạk-kĕn′-zee.
Madagascar, mad‵-ạ-gas′-kar.
Madeira, mä-dee′-rạ, or mä-dā′-rä.
Madrid, mä-drid′. (Spanish pron., mä-dreed′.)
Magdalena, mag-dạ-lee′-nạ.

Maggiore, måd-jo′-rå.
Malacca, må-lak′-ka.
Malay, ma-lå′.
Maldive, mal′-dīv.
Manitoba, man-e-to′-ba.
Mantchooria, man-choo′-re-a.
Maracaybo, må-rå-kī′-bo.
Marietta, må-re-ĕt′-ta.
Marquesas, mar-kå′-sås.
Marseilles, mar-sålz′.
Mauna Loa, mow′-nå lo′-å.
Mauritius, maw-rish′-e-ŭs.
Mediterranean, mĕd‵-e-tẹr-rå′-ne-an.
Melbourne, mĕl′-bŭrn.
Mesopotamia, mĕs‵-o-po-tå′-me-a.
Michigan, mish′-e-gan, formerly mish-e-gån′.
Mississippi, mis‵-sis-sip′-pee.
Missouri, mis-soo′-ree.
Mobile, mo-beel′.
Moluccas, mo-lŭk′-kaz.
Monte Rosa, mon‵-tå-rŏs′-så.
Mont Blanc, mônᵍ-blônᵍ′.
Moosehead, moos‵-hĕd′.
Moscow, mos′-kō.

N.

Nanling, nån‵-ling′.
Natchez, natch′-iz.
Netherlands, nĕTH′-ẹr-landz.
Neusalzwerk, noi′-sålts-verk.
Nevada de Sorata, ne-vah′-da dā so-rå′-tå.
Newfoundland, nu′-fond-land′.
Ngami, n′gå′-mee.
Niagara, nī-ag′-a-rah, originally ne-å-gå′-ra.
Nicaragua, nik-ar-å′-gwå.
Niemen, nee′-men.
Nieuveldt, nyuw′-velt.
Niger, nī′-ger.
Norfolk, nor′-fok.
Nova Scotia, no′-va sko′-she-a.
Nova Zembla, no′-va zĕm′-bla.
Nubia, nu′-be-a.
N'yassa, or **Nyassi**, ne-ås′-see.

O.

Obe, o′-bee.
Okefinokee, o‵-ke-fin-ō′-kee.
Okhotsk, o-KOTSK′. (Russian pron., o-HOTSK′.)
Onega, o-nå′-gå.
Onimak, oo-ne-måk′.
Ontario, on-tå′-rė-o.
Oregon, or′-e-gon.
Orinoco, or-e-no′-ko.

P.

Pamir, på-meer′.
Pamlico, pam′-lee-kō.
Pampas, păm′-pås.
Panama, pån-a-må′.
Papua, pap′-oo-a, or på‵-poo′-å.
Paraguay, på-rå-gwå′, or på-rå-gwī′.
Paramaribo, par‵-a-mar′-e-bo.
Pasco, pås′-ko.
Patagonian, på-tå-go′-ne-an.
Paumotu, pow-mȯ-too′.
Peling, på‵-ling′.
Persian, pẹr′-she-an.
Petchora, pĕtch′-o-rå.
Philippine, fil′-ip-pin.
Platte, platt.
Polynesia, pol‵-e-nee′-she-a.
Pompeii, pom-på′-yee.
Pontchartrain, pŏnt-chår-trån′.
Popocatepetl, po-po-kå-tå-pĕtl′.
Prussia, prŭsh′-ya, or proo′-she-a.
Pyrenees, pĭr′-en-eez.

Q.

Quebec, kwe-bĕk′.
Quito, kee′-to.

R.

Radack, rå′-dåk.
Ralick, rå′-lik.
Reading, rĕd′-ing.
Rhine, rīn.
Rhone, rōn.
Riobamba, re-o-båm′-bå.
Rio de la Plata, ree′-o då lå plå′-tå.
Rio Grande, ree′-o grån′-då.
Rio Janeiro, rī′o jå-nee′-ro.
Roanoke, ro‵-an-ōk′.
Rodriguez, ro‵-dreeg′.
Russia, rŭsh′-i-a, or roo′-she-a.
Russian America, roo′-shan a-mĕr′-e-ka.

S.

Sabine, så-been′.
Saghalien, så-gå-lee′-an, or så-gå-leen′.
Sahara, så-hå′-ra, or så′-ha-rå.
Saint Helena, sånt hel-ee′-na.
Salina, sa-lī′-na.
Salzburg, sålts′-bŭrg.
Samoan, sam-ō′-an.
Sandwich, sand′-wich, or sand′-wij.
San Francisco, sån från-sis′-ko.
San Joaquin, sån HO-å-keen′, almost wah-keen′.
Santa Barbara, sån′-tå bar-bå-rå.
Santa Cruz, sån′-ta kroos.
Santorini, sån-to-ree′-nee.
Sarmiento, sar-me-ĕn′-to.
Saskatchewan, sas-katch′-e-wŏn.
Scandinavian, skan-de-nå′-ve-an.
Seine, sån, or sĕn.
Senegal, sĕn‵-e-gawl′.
Shasta, shås′-ta.
Siam, sī-am′, or se-am′.
Sicily, sis′-il-e.
Sierra Estrella, se-ĕr′-rå ĕs-trĕl′-yå.
Sierra Leone, se-er′-ra le-o′-nee.
Sierra Madre, se-ĕr′-rå må′-drå.
Sierra Nevada, se-ĕr′-rå nå-vå′-då.
Singapore, sing‵-ga-pore′.
Sir, or **Sihon**, sĭr, or seer, see‵-hon′.
Sitka, sit′-ka.
Spitzbergen, spits-bẹrg′-en.
Steppes, steps.
St. Louis, sent loo′-is, or sent loo′-ee.
St. Petersburg, sent pee′-tẹrz-bŭrg.
St. Roque, sent rōk′.
St. Thomas, sent tom′-as.
Stromboli, strom′-bo-le.
Sumatra, soo-må′-tra.
Sumbawa, soom-baw′-wa.
Suez, soo′-ĕz.
Suliman, or **Suleiman**, soo-lå-mån′.
Syracuse, sĭr′ra-kūz.
Syria, sĭr′-e-a.

T.

Tahitian, tå-hee′-tee-an.
Tanganyika, tån-gån-yė′-kå.
Tarim, tå′-rėm.
Tasmania, taz-må-ne-a.
Taurus, taw′-rŭs.
Tchad, chåd.
Teneriffe, tĕn‵-ẹr-iff′.
Thames, tĕmz.
Thian-Shan, tee‵-ån′-shån.
Thibet, tib′-ĕt, or tib-ĕt′.
Timor, te-mōr′.
Titicaca, te-te-kå′-kå.
Tocantins, to-kån-teens′.
Toledo, to-lee′-do. (Spanish pron., to-lå′-DO.)
Tongan, tong′-gan.
Torrens, tor′-rens.
Torres, tor′-rĕs.
Transylvanian, tran-sil-vå′-ne-an.
Trieste, tre-ĕst′.
Trinidad, trin‵-e-dad′.
Tristan d'Acunha, tris′-tån då-kŭn′-yå.
Tundras, toon′-dra.
Tunis, tu′-niss, or too′-niss.
Turkestan, toor‵-kis-tån′.

U.

Urumiyah, oo-roo-mee′-ya̤.

V.

Valdai, vȧl′-dī.
Vancouvers, van-koo′-vẹrs.
Venezuela, vĕn‵-ĕz-wee′-la̤.
Vesuvius, ve-su′-vĭ-us.
Vichy, vee‵-shee′.
Vienna, vē-en′-na̤.
Vindhya, vĭnd′-yȧ.
Volga, vol′-gȧ.
Vosges, vōzh.

W.

Wabash, waw′-bash.
Wasatch, wȧ‵-sȧch.
Wener, ŵȧ′-nẹr.
Weser, wē‵-zẹr. (Ger. pron., ŵȧ′-zẹr.)
West Indies, west in′-deez.
Wetter, ŵĕt′-ter.
Winnebago, win‵-ne-bȧ′-go.
Winnipeg, win′-ẹ-peg.
Wisconsin, wis-kon′-sin.
Worcester, wŏŏs′-ter.

Y.

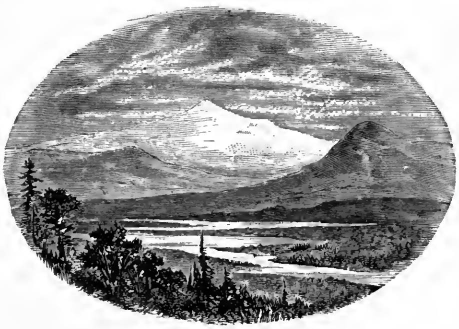
Yabloni, yȧ-blo-noi′.
Yaktusk, yȧ‵-kootsh′.
Yang-tse-Kiang, yȧng‵-tse-ke-ȧng′.
Yeddo, yĕd′-do.
Yellowstone, yel′-lo‵-stone.
Yenisei, yĕn‵-e-sȧ′-e, or yĕn‵-e-say′.
Yosemite, yo-sem′-e-te.
Yucatan, yoo-kȧ-tȧn′.
Yukon, yu′-kon.

Z.

Zagros, zȧ′-gros‵.
Zambezi, zȧm-bȧ′-zee.
Zealand, zē′-land.
Zurrah, zŭr′-ra̤.

BRIEF ETYMOLOGICAL VOCABULARY.

Amazon, "Boat destroyer."
Arabia, "The land of the sunset."
Brahmapootra, "The son of Brahma."
Cameroons, "A shrimp."
Deccan, "The south."
Ecuador, "The equator."
Elton, "Golden lake."
Formosa, "Beautiful" (island).
Gallapagos, "Islands of the tortoises."
Ganges, "Heavenward flowing."
Himalaya, "The abode of snow."
Hindostan, "The country of the Hindoos," or "Negro-land."
Hoang-Ho, "Yellow river."
Holland, "Muddy or marshy land."
Irrawaddy, "The great river."
Java, "Rice."
Labrador, "Cultivable."
Ladrones, "Islands of the thieves."
Lauterbrünnen, "Nothing but springs."
Maldives, "Thousand islands."
Mantchooria, "Country of the Mantchoos."
Mer de glace, "Sea of ice."
Mesopotamia, "Between the rivers."
Mississippi, "The great water."
Missouri, "Muddy water."
Netherlands, "The low countries."
Niphon, "Fountain or source of light."
Nova Scotia, "New Scotland."
Nyassa, "The sea."
Orinoco, "The coiled serpent."
Papua, "Frizzled hair."
Patagonians, "Men with large feet."
Polynesia, "Many islands."
Popocatepetl, "Smoking mountain."
Saskatchewan, "Swift current."
Sierra Nevada, "Snow-clad mountain."
Singapore, "City of the lion."
Staubbach, "Dust or mist brook."
Thian-Shan, "The celestial mountain."
Winnipiseogee, "The smile of the great Spirit."
Yang-tse-Kiang, "Son of the great water."



Statistical Tables.

Hydrographic Table of the Rivers of the World (from A. K. Johnston).

Name of River.	Area of basin in geographical square miles.	Length of stream including windings.
Rhine	65,280	600
Vistula	56,640	520
Elbe	41,860	684
Oder	39,040	480
Niemen	32,180	460
Seine	22,620	340
Nile	520,200 (?)	2,240 (?)
Danube	234,080	1,496
Dnieper	169,680	1,080
Obi	924,800	2,320
Yenisei	784,530	2,800
Lena	594,400	2,400
Volga	397,460	2,400
Sir or Sihon	237,920 (?)	1,208 (?)
Amoor	582,880	2,380
Yang-tse-Kiang	547,800	2,880
Hoang-Ho	537,400	2,280
Ganges	432,480	1,680
Indus	312,000 (?)	1,960
Euphrates	195,680	1,492
Irrawaddy	331,200	2,200
NEW WORLD.		
St. Lawrence and Great Lakes	297,600	1,800
Delaware	8,700	265
Orinoco	252,000	1,352 (?)
Amazon	1,512,000	3,080
Tocantins	284,480	1,120
San Francisco	187,200	1,400
La Plata	886,400	1,920
Mississippi	982,400	3,560
Rio del Norte	180,000	1,840 (?)
Mackenzie	441,600	2,120
Saskatchewan	360,000	1,664
Columbia	194,400	1,360
Colorado	170,000	800 (?)

Areas of the Principal Lakes of the Earth. (In English square miles.)

America.	Area sq. m.
Superior	28,600
Michigan	26,000
Huron	20,400
Great Slave	12,800
Erie	9,600
Winnipeg	9,600
Georgian Bay	8,000
Great Bear	8,000
Ontario	6,300
Maracaibo	4,900
Titicaca	4,200
Athabasca	3,000
Nicaragua	2,800
Great Salt	2,200
Green Bay	2,000
Champlain	480
Pontchartrain	440
Pyramid	360
Moosehead	240
Winnebago	212

Europe.	Area, sq. m.
Ladoga	6,330
Onega	3,280
Wener	2,136
Wetter	839
Malar	763
Geneva	326
Constance	290
Maggiore	152

Asia.	
Caspian Sea	160,000
Aral Sea	88,000
Baikal	13,000
Balkash	8,600
Zurrah (Afghanistan)	4,000
Wan	2,200
Urumiyah	1,800
Lop	560
Dead Sea	400
Tiberias	200

Africa.	
Victoria Nyanza	28,000
Albert Nyanza	26,000
Tchad	15,000
Tanganyika	13,000
Nyassa	5,000

Australia.	
Eyre	3,000
Torrens	2,600
Gairdner	2,400

Population of the Earth.

(From Bradley's Atlas.)

America	100,415,400
Europe	327,743,414
Asia	795,591,000
Africa	205,823,260
Pacific Islands	4,232,000
Total	1,433,805,074

Tables showing the Area and Product of some of the Cereals, etc., in the United States.

(From the Census Reports of 1880.)

INDIAN CORN.

State.	Acres.	Bushels.
Illinois	9,011,602	327,796,895
Iowa	6,616,364	276,093,295
Missouri	5,588,357	203,464,620
Indiana	3,679,247	117,121,915
Ohio	3,297,342	112,681,046
Kansas	3,417,700	106,791,482
Kentucky	3,021,350	73,977,829
Nebraska	1,631,840	65,785,572
Tennessee	2,905,038	62,833,017
Pennsylvania	1,374,241	47,970,987

WHEAT.

State.	Acres.	Bushels.
Illinois	3,218,963	51,136,455
Indiana	2,619,307	47,288,989
Ohio	2,556,134	46,014,869
Michigan	1,822,752	35,537,097
Minnesota	3,046,821	34,625,657
Iowa	3,049,347	31,177,225
California	1,837,322	28,787,132
Missouri	2,074,314	24,971,727
Wisconsin	1,948,036	24,884,689
Pennsylvania	1,445,384	19,462,405

OATS.

State.	Acres.	Bushels.
Illinois	1,959,853	63,206,250
Iowa	1,507,490	50,612,141
New York	1,261,171	37,575,506
Pennsylvania	1,237,593	33,847,439
Wisconsin	955,276	32,911,246
Ohio	910,388	28,664,505
Minnesota	617,427	23,372,752
Missouri	968,473	20,673,458
Michigan	536,167	18,190,493
Indiana	623,600	15,606,721

BARLEY.

State.	Acres.	Bushels.
California	586,045	12,578,486
New York	356,556	7,788,749
Wisconsin	204,323	5,043,202
Iowa	198,885	4,021,473
Minnesota	116,024	2,973,061
Nebraska	115,288	1,744,711
Ohio	57,485	1,707,164
Illinois	55,278	1,229,693
Michigan	54,509	1,204,523
Oregon	29,311	920,977

RYE.

State.	Acres.	Bushels.
Pennsylvania	398,465	3,683,621
Illinois	192,138	3,121,682
New York	244,894	2,634,390
Wisconsin	169,693	2,298,544
Iowa	102,580	1,518,307
New Jersey	106,029	949,104
Kentucky	89,579	676,245
Missouri	46,488	535,458
Nebraska	34,372	424,693
Kansas	34,628	413,181

BUCKWHEAT.

State.	Acres.	Bushels.
New York	291,228	4,461,200
Pennsylvania	246,199	3,593,328
New Jersey	35,373	466,414
Michigan	33,955	413,180
Maine	20,135	382,701
Vermont	17,630	356,618
Wisconsin	34,119	299,150
West Virginia	30,334	285,298
Ohio	22,130	280,229
Illinois	16,464	178,964

TOBACCO.

State.	Acres.	Pounds.
Kentucky	226,127	171,121,134
Virginia	139,423	80,099,838
Pennsylvania	27,567	36,957,772
Ohio	34,679	34,725,405
Tennessee	41,532	29,365,052
North Carolina	57,215	26,986,448
Maryland	38,174	26,082,147
Connecticut	8,666	14,044,652
Missouri	15,500	11,994,077
Wisconsin	8,811	10,878,463

Population of the United States.

(From the Census of 1890.)

North Atlantic States	17,401,545
Maine	661,086
New Hampshire	376,530
Vermont	332,422
Massachusetts	2,238,943
Rhode Island	345,506
Connecticut	746,258
New York	5,997,853
New Jersey	1,444,933
Pennsylvania	5,258,014
South Atlantic States	8,857,920
Delaware	168,493
Maryland	1,042,390
District of Columbia	230,392
Virginia	1,655,980
West Virginia	762,794
North Carolina	1,617,947
South Carolina	1,151,149
Georgia	1,837,353
Florida	391,422
North Central States	22,362,279
Ohio	3,672,316
Indiana	2,192,404
Illinois	3,826,351
Michigan	2,093,889
Wisconsin	1,686,880
Minnesota	1,301,826
Iowa	1,911,896
Missouri	2,679,184
North Dakota	182,719
South Dakota	328,808
Nebraska	1,058,910
Kansas	1,427,096
South Central States	10,972,893
Kentucky	1,858,635
Tennessee	1,767,518
Alabama	1,513,017
Mississippi	1,289,600
Louisiana	1,118,587
Texas	2,235,523
Indian Territory	———
Oklahoma	61,834
Arkansas	1,128,179
Western States	3,027,613
Montana	132,159
Wyoming	60,705
Colorado	412,198
New Mexico	153,593
Arizona	59,620
Utah	207,905
Nevada	45,761
Idaho	84,385
Alaska	———
Washington	349,390
Oregon	313,767
California	1,208,130
Total population of the United States	62,622,250

Cities of the United States having a Population over 50,000, in order of Population.

(From the Census of 1890.)

NO.	CITIES.	POPULATION.
1.	New York City, N. Y.	1,513,501
2.	Chicago, Ill.	1,098,576
3.	Philadelphia, Pa.	1,044,894
4.	Brooklyn, N. Y.	804,377
5.	St. Louis, Mo.	460,357
6.	Boston, Mass.	446,507
7.	Baltimore, Md.	434,151
8.	San Francisco, Cal.	297,990
9.	Cincinnati, O.	296,309
10.	Cleveland, O.	261,546
11.	Buffalo, N. Y.	254,457
12.	New Orleans, La.	241,995
13.	Pittsburgh, Pa.	238,473
14.	Washington, D. C.	229,796
15.	Detroit, Mich.	205,669
16.	Milwaukee, Wis.	204,150
17.	Newark, N. J.	181,518
18.	Minneapolis, Minn.	164,738
19.	Jersey City, N. J.	163,987
20.	Louisville, Ky.	161,005
21.	Omaha, Neb.	139,526
22.	Rochester, N. Y.	138,327
23.	St. Paul, Minn.	133,156
24.	Kansas City, Mo.	132,416
25.	Providence, R. I.	132,043
26.	Indianapolis, Ind.	107,445
27.	Denver, Cal.	106,670
28.	Allegheny City, Pa.	104,967
29.	Albany, N. Y.	94,640
30.	Columbus, O.	90,398
31.	Syracuse, N. Y.	88,387
32.	Worcester, Mass.	84,536
33.	Scranton, Pa.	83,450
34.	Toledo, O.	82,652
35.	New Haven, Conn.	81,451
36.	Richmond, Va.	80,838
37.	Paterson, N. J.	78,358
38.	Lowell, Mass.	77,605
39.	Nashville, Tenn.	76,309
40.	Fall River, Mass.	74,351
41.	Cambridge, Mass.	69,837
42.	Atlanta, Ga.	65,514
43.	Memphis, Tenn.	64,586
44.	Grand Rapids, Mich.	64,147
45.	Wilmington, Del.	61,437
46.	Troy, N. Y.	60,605
47.	Reading, Pa.	58,926
48.	Dayton, O.	58,860
49.	Trenton, N. J.	58,488
50.	Camden, N. J.	58,274
51.	Lincoln, Neb.	55,491
52.	Lynn, Mass.	55,684
53.	Charleston, S. C.	54,592
54.	Hartford, Conn.	53,182
55.	St. Joseph, Mo.	52,811
56.	Evansville, Ind.	50,674
57.	Los Angeles, Cal.	50,394
58.	Des Moines, Ia.	50,067

North
Pole
South
pole

[illegible] 1312 ft below sea) — [illegible] at 2 the

[illegible] above

[illegible] high in

[illegible] back [illegible]

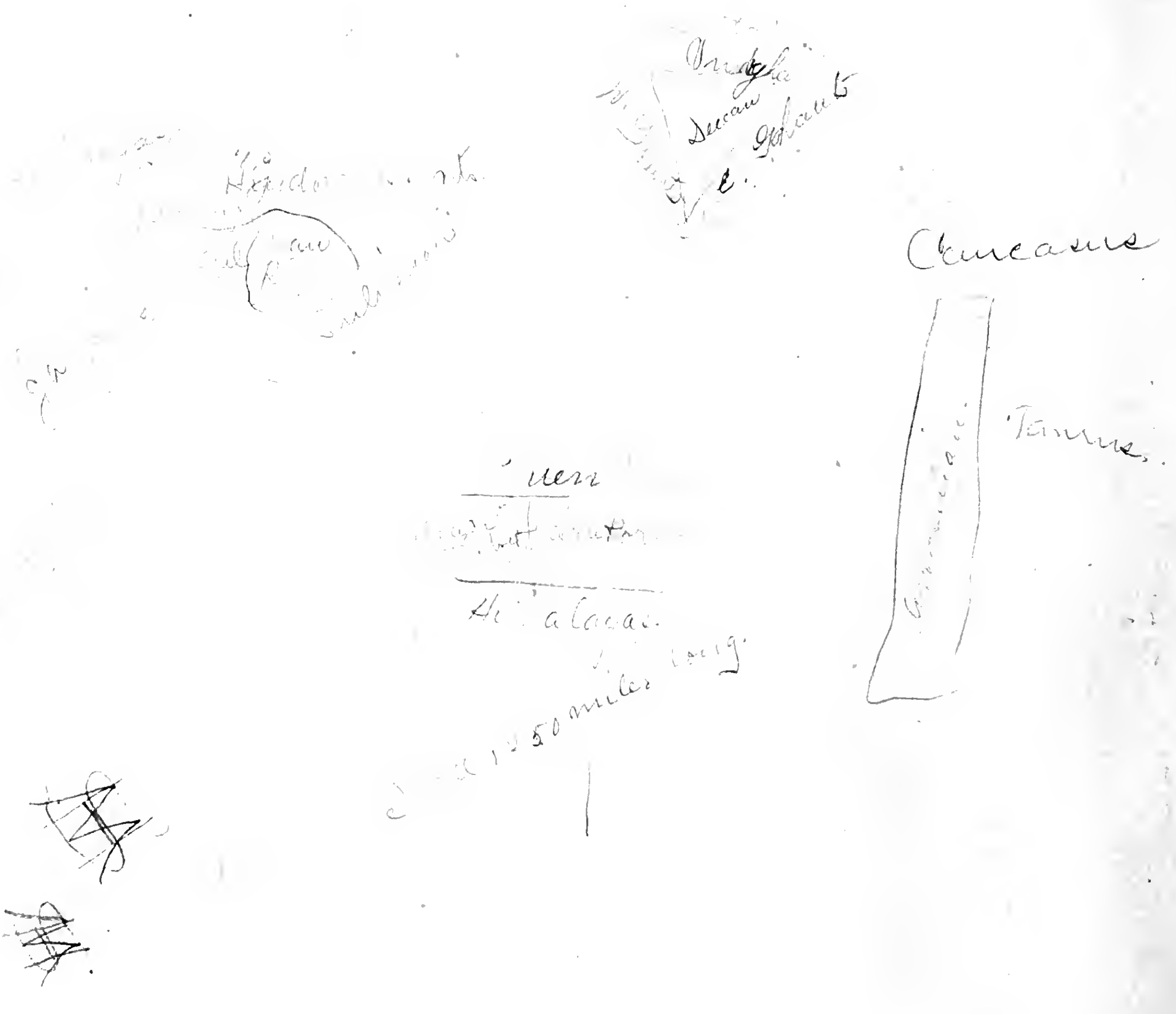
[illegible] miles long

[illegible] the water [illegible] salt

[illegible] supporting any life —

[illegible] 1300 ft. below [illegible]

[illegible]



Quod erat faciendum - which was do[illegible]

Eastern Hemi.

cape Chelyuskin - 77° 16' N. lat.
" Agulhas 34° 51' S. lat.
" East 170° W. long.
Cape Verd - 17° 34' W. long.

Western Hemi.

Point Barrow 72° N.

Aust. - 3 -
Europe - 3.7
South A - 6.5
North A - 8.4
Africa - 12
Asia - 17.5

} million sq. mi.