

other green. Some of the single stars look blood-red; but there are none that exhibit deep tinges of blue or green.

The size of several of the fixed stars has been calculated approximately. Their diameters are found to be enormous,—in one case not less than 200,000,000 miles. Sirius, “the dog-star”, if set in the place of our Sun, would look 125 times as large as he, and give us 125 times as much light. Trillions of miles away, as it is, it dazzles the eye when seen through a powerful telescope.

1013. THE GALAXY.—The Galaxy, or Milky Way, is a broad zone of light which stretches across the sky from horizon to horizon, encircling the whole sphere and maintaining the same position relatively to the stars. Examined through a powerful telescope, it is found to consist entirely of stars, scattered by millions, like glittering dust, on the black ground of the heavens.

1014. NEBULÆ.—Nebulæ are clusters of stars so distant that they look like faint patches of cloud hardly discernible in the sky. They vary in shape, and are seen in different quarters of the heavens.

Lord Rosse’s great telescope resolves some of the nebulae into individual stars; it makes others appear bright, but not sufficiently so to be separated into the stars that compose them; and it calls up from the depths of space others which appear as faint even to its mighty magnifying power as those which it resolves appear to the unaided eye. The milky way is itself one of these nebulae, more distinct than the others because nearer to us.

From the facts set forth we may conclude that the universe consists of a vast number of distinct clusters of worlds, separated from each other by immense intervals; that the fixed stars, the milky way, our Sun and its system, form one of these clusters; that the various nebulae constitute other clusters, fainter or brighter according to their distance from us,—each composed of many different systems,—and having its members separated as widely as our Sun is from the brother suns about him.

How can the mind take in such mighty thoughts! How can the heart refuse its homage to the great Creator of all these worlds!

many of the binary stars tinged? What has been found with respect to the diameters of some of the fixed stars? How would Sirius look, if set in the place of our Sun? 1013. What is the Galaxy? How does it look through a powerful telescope? 1014. What are Nebulae? How do nebulae look through Lord Rosse’s telescope? What may we conclude from the facts set forth?

## CHAPTER XIX.

## METEOROLOGY.

1015. METEOROLOGY is the science which treats of the phenomena of the atmosphere. Among these are winds, clouds, fog, dew, rain, snow, and hail.

Some of the phenomena of the atmosphere have been already described and explained in connection with the various subjects that have engaged our attention.

1016. WIND.—Wind is air put in motion.

The motion of the air is the result of changes constantly going on in the earth’s temperature, in consequence of the alternation of day and night and the succession of the seasons. Those portions of the atmosphere that rest on the hotter regions of the earth become heated and rarefied, and rising leave a vacuum which is immediately filled by a rush of cooler air from the surrounding parts. Currents are thus produced, which we call *winds*.

The direction of the wind is determined by various local causes, modified by the revolution of the earth on its axis. The latter, operating alone, would make it appear to blow uniformly from the east; but the various projections on the earth’s surface, and the unequal distribution of land and water (the latter of which is incapable of being heated to the same degree as the former),—these and other agencies constantly at work combine to give the wind different directions at different places, and to make it vary at the same place.

1017. *Velocity*.—The velocity of the wind is measured with an instrument called the Anemometer.

There are several kinds of anemometers. One of the best consists of a small windmill, with an index attached for recording the number of revolutions made in a second.

It is found with the anemometer that a wind so slight as hardly to stir the leaves travels at the rate of 1 mile an hour; a gentle wind, 5 miles in the same time; a brisk gale, 15 miles; a high wind, 30; a storm, 50; a hurricane, 80; a violent hurricane, 100.

1018. *Kinds*.—There are three kinds of winds; Constant, Periodical, and Variable.

1015. What is Meteorology? Mention some of the phenomena of the atmosphere. 1016. What is Wind? What puts the air in motion? By what is the direction of the wind determined? 1017. How is the velocity of the wind measured? What is one of the best forms of the anemometer? How fast does a scarcely perceptible wind travel? A gentle wind? A brisk gale? A storm? A hurricane? 1018. How many



1019. Constant Winds are those that blow throughout the year in the same direction.

The most noted of these are the Trade Winds, which extend about 30 degrees on each side of the equator, a zone of 6 degrees near the centre known as the Region of Calms being excepted. They blow uninterruptedly on the ocean from north-east to south-west in the northern hemisphere, and from south-east to north-west in the southern. The regions on the equator being more heated than the surrounding parts, the air resting on them is rarefied, and rising flows over the cooler masses towards the poles, while cold air from the latter rushes in below to supply its place. Were the earth stationary, the trade winds would be due north on one side of the equator, and due south on the other. The earth's diurnal revolution, however, from west to east, modifies these directions so far as to make the north wind north-east and the south wind south-east.

The trade winds are of great service to mariners, enabling them to make certain voyages (for instance, from the Canaries to the northern coast of South America) with great rapidity, and almost without touching a sail. The zone in which they prevail is noted for its transparent atmosphere, its uniformity of temperature, and general peaceful aspect; whence it has been called by the Spaniards "the sea of the ladies".

1020. Periodical Winds are such as blow regularly in the same direction at a certain season of the year or hour of the day. The monsoon, the simoom, and the land and sea breezes, are periodical winds.

The monsoons are modifications of the trade winds, which sweep, sometimes with great violence, over the Indian Ocean and the whole of Hindostan. For six months they blow from a certain quarter, and for the next six months from the opposite one, owing to the change in the sun's position, and consequently in the heat received at a given point.

The simoom, originating in the deserts of Asia and Africa, is distinguished by its scorching heat and the fine sand it carries with it, raised from the parched surfaces it traverses. The simoom from the Desert of Sahara, sweeping over the intervening regions, finally reaches the northern shore of the Mediterranean, and is there called the Sirocco.—During the continuance of this hot and deadly wind, the animal and the vegetable creation droop with excessive exhaustion; travellers on the desert save their lives only by throwing themselves down with their faces in the sand.

Land and sea breezes are produced by the unequal heating of land and

kinds of winds are there? Name them. 1019. What are Constant Winds? What are the most noted constant winds? Where do the trade winds blow, and in what direction? Explain the origin of the trade winds. How do they benefit mariners? What do the Spaniards call the region in which they prevail, and why? 1020. What are Periodical Winds? Mention some. Describe the monsoons. Where does the simoom originate, and by what is it distinguished? What is the Sirocco? What is

water. During the day, the land receives more heat than the adjacent ocean, the rarefied air in contact with it rises, and a gentle breeze sets in from the sea about nine in the morning, which gradually increases to a brisk gale in the middle of the day. About 3 p. m. it begins to subside, and is followed in the evening by a land breeze, which blows freshly through the night: for after sunset the land rapidly parts with its heat by radiation, and the air resting on it, becoming cooler than that on the ocean, rushes to supply the place of the latter when it rises in consequence of being rarefied.

1021. Variable Winds are those which are irregular as to time, direction, and force, seldom continuing to blow for many days together. They prevail chiefly in the temperate and frigid zones, the winds of the torrid zone being for the most part constant or periodical.

1022. *Hurricanes*.—Hurricanes are storms that revolve on an axis, while at the same time they advance over the earth's surface.

Hurricanes are distinguished by their tremendous velocity and great extent. They are often 500 miles in diameter, and sometimes much more. In the southern hemisphere they always revolve in the same direction as the hands of a watch; in the northern hemisphere, in the opposite direction. There are three hurricane regions; the West Indies, the Indian Ocean, and the China Sea. In the last they are called Typhoons.

1023. *Tornadoes*.—Tornadoes, or Whirlwinds, are as violent as hurricanes, but more limited in extent. They are rarely more than a few hundred yards in breadth and twenty-five miles in length. Though lasting but a few seconds in a given place, they are frequently most disastrous in their effects, prostrating forests, overturning buildings, and ravaging the whole face of the country.

1024. *Water-spouts*.—A Water-spout is a phenomenon frequently observed at sea, consisting of a column of water raised sometimes to the height of a mile and tapering from each end towards the centre. It is supposed by some to be produced by a whirlwind of great intensity; by others it is attributed to electrical influences.

the effect of the simoom on the animal world? When do land and sea breezes blow, and how are they produced? 1021. What are Variable Winds? Where do they chiefly prevail? 1022. What are Hurricanes? By what are they distinguished? In what direction do they revolve? Name the three hurricane regions. 1023. What are Tornadoes? Describe their effects. 1024. What is a Water-spout? By what is it produced? Give an account of the way in which it is formed. 1025. What does



Water-spouts are formed as follows:—From a dark cloud a conical pillar is seen to descend with its point downward. As it approaches the water, the latter becomes violently agitated, and a similar column rises from it, point upward. The two finally unite, forming a continuous column from the cloud to the water. After remaining joined for a time, they again separate into two columns, one of which is drawn up into the cloud, while the other pours down in the form of heavy rain. Sometimes the two columns are dispersed before a junction is effected.

1025. *ATMOSPHERIC MOISTURE.*—The atmosphere always contains more or less moisture, derived from the earth's surface, particularly those portions of it that are covered with water, by the process of evaporation. When the air contains as much moisture as it is capable of holding at any given temperature, it is said to be *saturated*.

The higher the temperature of air, the more moisture it is capable of receiving. At 32° F., it will hold only  $\frac{1}{100}$  of its own weight of watery vapor; while at 113° it will receive eight times as much, or  $\frac{1}{20}$  of its own weight.

1026. The earth gives out incredible quantities of moisture by evaporation. Experiments prove that an acre of ground apparently parched by the sun sends forth into the air over 3,000 gallons of water in 24 hours. Of course much greater quantities are evaporated from a moist soil and from surfaces covered with water.

1027. *The Hygrometer.*—The amount of moisture in the atmosphere is ascertained with an instrument called the Hygrometer. Hygrometers are made on different principles.

In some, the degree of humidity is indicated by the elongation of a hair, a fibre of whalebone, or some other animal substance which readily absorbs moisture and is increased in length by so doing. In others, it is shown by the increase of weight in some substance that absorbs moisture, such as sponge, cotton, or potash. In the more delicate instruments, the degree of moisture is shown by the greater or less facility with which it is condensed from the air in the form of dew on a cold surface. The more moisture in the air, the less cold will be required to condense it into dew.

1028. *Fog—Clouds.*—When the air is cooler than the earth, the moisture imparted to it in the manner just described is partially condensed and thus rendered visible, forming either *fog* or *clouds*. The only difference between the two is in their height. When the condensation takes

the air always contain? When is it said to be *saturated*? On what does the amount of moisture that air can receive depend? 1026. How much moisture does the earth give out by evaporation? 1027. What is the Hygrometer? Mention the different principles on which the hygrometer is made. 1028. When are Fog and Clouds

place near the earth's surface, fog is the result; when in the upper regions of the atmosphere, clouds.

1029. *Kinds of Clouds.*—Clouds are divided into different classes, the principal of which are the Nimbus, the Cumulus, the Stratus, and the Cirrus.

The Nimbus, or rain-cloud, is a dense mass of vapor, of a leaden gray or blackish color, with a lighter tint on its edges.—The Cumulus has the appearance of many dense whitish clouds piled up one on another; or of a vast hemisphere with its base on the horizon, and peak rising above peak, looking like huge hills of snow when illumined by the sun. The cumulus may be called the cloud of day, and is an indication of fair weather.—The Stratus consists of a number of horizontal layers of cloud, not very far removed from the earth's surface. Forming at sunset and disappearing at sunrise, it may be called the cloud of night.—The Cirrus (called *cat's tail* by sailors) is a fleecy cloud, composed of thin feathery filaments disposed in every variety of form. The cirrus is the highest of all clouds, frequently reaching an altitude of from three to five miles. It is no doubt often composed of snow-flakes, as the temperature of the regions in which it floats must be cold enough to freeze the watery particles.

1030. *Dew.*—When the moisture of the atmosphere comes in contact with an object colder than itself, it is condensed and deposited on the surface. This is the way in which Dew is formed.

A glass of ice-water on a warm day is almost immediately covered with a fine dew. So, in winter, when a number of persons are in a warm room, the moisture imparted to the air by their breath is condensed on the window-panes by the cold air without, and then sometimes frozen, giving them a beautiful frosted appearance.—Just so, in the evening, when objects on the earth's surface are cooled down by radiation, the moisture of the atmosphere is deposited on them in the form of dew.

1031. Dew is never abundant except during calm serene nights. It is generally more plentiful in spring and autumn than in summer, because the difference between the temperature of day and night is greater in those seasons. The quantity of dew precipitated on different bodies depends much upon their nature. Thus grass and leaves will frequently be found glistening with crystal drops at sunrise, when gravelled walks, stones, wood-work, and metallic surfaces, are comparatively dry—another striking proof of the wisdom with which Providence orders the economy of nature.

1032. Frost is nothing more than frozen dew.

formed? What is the difference between them? 1029. Name the different kinds of clouds. Describe the Nimbus. The Cumulus. The Stratus. The Cirrus. 1030. Under what circumstances is Dew formed? What familiar instances of the formation of dew are mentioned? 1031. When is dew most abundant? How does its precipi-



1033. RAIN.—Rain is water taken up by the air in the form of vapor and returned to the earth in drops.

When two masses of damp air differing considerably in temperature are mingled, they become incapable of retaining the same amount of moisture which they held while they remained apart. The excess is precipitated in the form of rain, the vesicles of vapor under the influence of mutual attraction blending together and forming drops.

Some parts of the earth never have any rain, vegetation, when it exists at all, being supported entirely by dew. This is the case with Peru, the Desert of Sahara, portions of Arabia and Egypt, and extensive districts in Central Asia. In other parts, for example Guiana, it rains almost constantly. The Island of Chiloe has a rather moist climate; the people there have a current saying, that it rains six days in the week and is cloudy the seventh.

1034. SNOW.—Snow consists of the watery particles of the atmosphere frozen for the most part in a crystalline form.

Viewed through a microscope, snow-flakes exhibit forms of great beauty and endless variety. Between six and seven hundred different forms have been distinguished, many of them belonging to the six-sided system of crystals.

Snow of a beautiful crimson color and a delicate green has been found in different parts of the world. These tints are due to minute plants or animalcules in different stages of development.

1035. HAIL.—Hail consists of globules of ice formed in the atmosphere by the congelation of its moisture and precipitated to the earth.

Hail is produced by an intense degree of cold in the atmosphere, and is generally accompanied with electrical phenomena. It is rare at the level of the sea within the tropics, and in high latitudes is totally unknown, being most abundant in temperate climates. Hail-storms seldom continue a quarter of an hour, but while they last large quantities of ice fall. The stones are generally pear-shaped, and frequently weigh ten or twelve ounces. Masses weighing 6, 8, and even 14 pounds, have been known to fall.

tation show the goodness of Providence? 1032. What is Frost? 1033. What is Rain? How is rain formed? What parts of the earth never have any rain? Where does it rain almost constantly? 1034. Of what does Snow consist? What is the form of snow-flakes? Of what color has snow sometimes been found? How is this accounted for? 1035. Of what does Hail consist? How is it produced? Where is it most frequent? What is the shape of hail-stones? How large have they been known to fall?

## FIGURES.

For the convenience of the pupil during recitation, the Figures to which reference is made by letters are here reproduced. The numbers correspond with those of the text.

