RAINFALL.

ALL storms are due to the combined action of heat and moisture. Suppose that the ground at a certain place is more heated than elsewhere in the neighborhood. This might happen from some difference in the nature of the surface or of the rocks. The heated ground heats the air above it. The air expands, and there is not only an upward current, but the whole atmosphere is raised up in consequence of the expansion. The atmosphere, being higher over this place than about it, flows off all around at the top. The consequence is that the pressure on the air is less at that place because there is less atmosphere, part of it having flowed off. In consequence of this diminished pressure the air flows in, near at the surface of the earth, from other places all around where the pressure is greater, and thus a wind towards the heated place is produced. So, if any place is cooler than other places about it, the air above it is cooled and contracts, the top of the atmosphere becomes lower, and air flows in at the top. There is consequently a greater atmospheric pressure at that place than elsewhere in the neighborhood, and consequently an outward wind springs up. I have spoken as though the disturbance necessarily extended to the very top of the atmosphere. This is not necessarily so, but everything which we readily see at the surface is just as if it were so, and happens too in consequence of the same mechanical principles, as if the top of the air were really raised or lowered.

Suppose, next, that instead of a place being hotter or cooler than surrounding places, there is a body of water surrounded by very dry land. Evaporation will take place from the surface of that water. The air becomes mixed with aqueous vapor, of which a certain amount is added to it. There is consequently so much added to the weight of the atmosphere at that point, and there will be greater atmospheric pressure at that place than at surrounding places. If, therefore, the aqueous vapor had the same specific gravity as air, there would be a gentle wind away from such a body of water exactly representing the amount of aqueous vapor added to the atmosphere. But aqueous vapor is in reality only two thirds of the specific gravity of air, so that the pressure of the atmosphere is increased by only two thirds of the amount that it would be in the other case; and as the atmosphere from the lake has a larger proportion of aqueous vapor than from the surrounding land, and therefore a less specific gravity, the surface of the atmosphere will be elevated so as to make an equal weight on the different parts of the earth's surface. The atmosphere will therefore flow off at the top from this place. But we have hitherto failed to take account of two important circumstances, viz. the fact that the air is everywhere colder as we ascend from the surface of the earth, and the fact of the condensation of aqueous vapor at lower temperatures into rain or snow. The reason why the atmosphere is colder at higher latitudes than at lower ones is this. If you put a pressure upon any gas so as to condense it, if, for example, you have air in a cylinder in which a piston works and forcibly press down the piston, heat will be produced in an amount which is the equivalent of the work which has been expended in pressing down the piston, and conversely, if you take the pressure off, the condensed gas which is allowed to expand itself performs a certain amount of work, and the equivalent of that work in heat is lost to the gas, so that it is cooled. Now the pressure under which the atmosphere is, is owing entirely to its gravitation, so that in the higher parts of the atmosphere there is less pressure than in the lower parts. Suppose, therefore, that a certain amount of air be carried up through the surface a thousand feet, an equal amount of air will go down to fill its place. The air which goes up will be under less pressure and will expand, and in doing so will do a certain work, viz. that of assisting to support the upper strata of air, which the other body of air, which has been carried down, previously did, and the air that is carried up will lose an equivalent amount of heat in consequence, while the air that is carried down will gain the same amount. Now there are so many upward and downward currents in the air, that the heat in this way gets so distributed that when there is an upward current of air, and the air in consequence of going upward is expanded and becomes cooler, it finds itself in general at the same temperature as the air which is already at that same elevation. When the aqueous vapor over our lake, therefore, rises, in consequence of its lightness, it is cooled, and if it rises high enough is so much cooled as to be condensed into water, which falls to the ground, and there is then a deficiency of atmospheric pressure at that place, and the wind will blow in towards the lake to supply the loss. Now let us consider the combined action of heat and moisture in producing storms. A place being heated, a wind inwards and upwards is produced there, and in consequence of the greater heat, greater evaporation goes on there. The moisture which is carried up becomes condensed in rain, and keeps the air at the surface continually saturated. The storm will therefore continue, when it has once been begun, as long as moisture is supplied. This is the explanation of the essential features of a storm, but there are two very noticeable circumstances about storms which we have not yet noticed. The first is the rotatory movement of the wind about the centre of a storm, and the second is the movement of the centre itself. The rotatory or cyclonic character of storms is due to the rotation of the earth. If we were standing at the North Pole the stars would appear to move round in horizontal circles from left to right, but this would of course really be due to the rotation of the earth from right to left. In any other northern latitude the stars generally appear to move round in the same direction as at the pole, so that the ground really is moving around from right to left under our feet. At the equator there is no such rotation, and in the Southern Hemisphere its direction is reversed. In consequence of this, if we take a pendulum which is free to move in all directions and swing it, the momentum of the bob will tend to keep it moving on in one plane, and as the earth revolves from right to left under it, the plane will appear to rotate (when its direction is referred to terrestrial objects) from left to right, or, in other words, there will be a continual apparent deflection of the motion of the bob towards the right in the Northern Hemisphere. It is just the same with any other object which is moving with a high degree of momentum. It will always tend to be deflected to the right when the direction of the motion is referred to terrestrial objects, and as the particles of air in a storm have a high velocity, any current of air will be deflected to the right. Consequently, when the wind blows inwards towards the warm centre, that which blows from the south will be deflected towards the east, that which blows from the east will be deflected towards the north, that which blows from the north will be deflected towards the west, and that which blows from the west will be deflected towards the south, and so there will be a rotation of the wind about the centre of the storm from south to east, from east to north, from north to west, and from west to south. In other words, the wind will blow round from right to left. Although this motion is originally due to the deflection of each of its particles from left to right when the wind blows outwards from the cooled centre, that which blows towards the north is deflected to the east, that which blows towards the east is deflected to the south, that which blows to the south is deflected to the west, and that which blows to the west is deflected to the north, so that there is a whirlwind from right to left, or in the opposite direction to the whirl about the warm centre, and yet these two opposite whirls are equally due to the deflection of the separate particles towards the right. Whoever will look over a series of General Myer's weather-maps will find it an invariable rule, that whenever there is a wind the barometer is lower where the wind is blowing to, than where it is blowing from; and it is an equally invariable rule, that the barometer is higher on the right-hand side of a current than on its left-hand side. It is also a general fact, that at a centre of high pressure the wind blows directly outwards, while at a centre of low pressure it blows much more round the centre. These facts are precisely what the theory requires.

The motion of the centres of storms is partly due to the motions of the great currents of air which are owing to the general distribution of heat upon the surface of the earth, and to the rotation of the earth, but it is doubtless also due to the tendency which the centre of a storm will have to move to where it is warmer and moister.

The amount of rain which falls at any place and at any season of the year depends first upon there being evaporation sufficient to produce the rain, and second upon there being condensation of the moisture after it has evaporated. On account of the necessity of moisture there will be more rain in the neighborhood of rivers than elsewhere. This is especially the case in reference to the great rivers which fall into the Gulf of Mexico. Mr. Schott of the Coast Survey, in his work upon the rainfall of the United States, published by the Smithsonian Institution, has given maps showing, by shading, the rainfall in different parts of the United States for the whole year, for the three summer months and for the three winter months. It is a curious fact that there is a remarkable and even a minute resemblance between the map of the rainfall during the three winter months and the map of the distribution of illiteracy over the United States, given in the census of 1870. Such a resemblance could not exist unless the rainfall, or the cause of it, had some influence direct or indirect upon illiteracy. It may be, for example, that where there is a copious winter rainfall, agriculture becomes more easy, and that where the earning of a bare subsistence requires so little effort there is a greater proportion of the population who are in a degraded state.

There is nothing more characteristic of the climate of the United States east of the Mississippi and north of the cotton States, than the equality with which the rainfall is distributed through the year. Nevertheless, the new reductions and generalizations of the observations worked out by Mr. Schott show that there are, at least upon the Atlantic seaboard, three yearly maxima and three minima of rainfall. Though these comparatively rainy and dry seasons begin and end gradually, and are, moreover, some years earlier and some years later, yet any one who has lived long near the Atlantic coast will recognize them easily. If we leave out of account every other month, beginning with January, as of undecided character, the remainder are alternately dry and wet. Of course, no month is dry in the sense in which the summer is dry in California and in Southern Europe, nor is any month wet as July is wet in Florida; still the distinctions are quite clear. February has much cold, settled, clear weather. April is celebrated for easterly storms and showers. The fine days and beautiful nights of June are remembered by everybody. August is the month of heavy and often prolonged thunder-storms, the time of dog-days. October is clear and dry, the Indian summer. December is a very stormy month. For a large part of the country the year might perhaps be better divided into six seasons than into four. On the coast of Maine, where the winter is earlier and the spring later, the distinction between the stormy season of November and December and the sharp frosts of midwinter is even more marked, but there is no more rain in the dog-days than in June. Passing southward, on the other hand, to Carolina, Georgia, and Florida, the dog-days gradually assume the character of a tropical rainy season.

At Fort McHenry, Md.,	4.2	inches rain falls in August.
" Fortress Monroe, Va.,	5.7	" " " " "
" Fort Moultrie, S. C.,	7.6	" " " " "
" Charleston, S. C.,	7.0	" " " " "
" Savannah, Ga.,	8.3	" " " " "
" Fort Brooke, Fla.,	10.6	" " " " "

In that part of the country the spring is so early and the autumn so late, that the other seasons are crowded and confounded together in great measure. The only other features strongly marked are dry seasons, which precede and follow the summer rainy season, and a pretty wet winter. A closer examination, however, seems to reveal traces of all the seasons which we have at the North. Passing round to the Gulf coast, we find the rainy season of July and August still extremely developed, though somewhat less so than in Georgia, but we now have an almost equally rainy season in December. This is undoubtedly identical with the so-called subtropical rainy season. But it is equally certain that it is the same as the stormy December of the North. In New Orleans and Baton Rouge, the dry February, the wetter April, and the less wet May are also plainly distinguishable. Farther up the Mississippi, at Natchez and Vicksburg, the summer rains are much diminished. December is the wettest season, and the April maximum exceeds that of August, but all the time between December and April is wet. Let us now return to Boston, and trace the effect of passing into the interior. In Boston the three dry seasons are equally dry, and of the three wet seasons April is a little wetter than August and August than December. Already at Cambridge, three miles distant, a difference begins to be perceptible. October is a little less dry than the other dry seasons, and of the three wet seasons August is decidedly the wettest, December next, and April the least so. At Worcester the wet seasons have the same order of intensity; of the dry seasons, October is the least dry, and February the most. At Amherst these differences are much exaggerated, for February is by far the driest time, and July the wettest. This dog-day period, moreover, is extended earlier, so that the June minimum disappears. At Williamstown, both the June and October minima vanish, and there is simply a wet summer and a dry winter, the other differences being barely traceable. This is the general type of the seasons throughout the West, with various modifications, however. In northern districts there is, for instance, a somewhat less rainy interval in the middle of summer. In the valley of the Mississippi the December rains appear again, and October is the driest season. Farther west the system of seasons seems to be quite different. In Arkansas, April and November are the times of maximum rainfalls, September and January minimum. In Indian Territory the maxima fall is in May and October, the minima in August and January. In California the maximum is in December, and there is no rain at all from the 1st of June to the 1st of October. In Washington Territory the maximum is in December, the minimum in July or August. At Sitka the maximum is early in October, the minimum last in June; but three and one half inches fall even in that month.