SCIENCE

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THUNDER-STORMS.

A TYPICAL thunder-storm is first seen as a dense, ragged cloud in the west, extending to a height of over a mile. The sky is entirely clear elsewhere, except sometimes covered by a light fleecy veil of cirrus. The cloud in the west rapidly enlarges, and completely covers the sky except a small portion to the east and south-east. The motion of these clouds is distinctly from the west and quite rapid, while the surface wind is from the south and quite gentle. This wind is blowing toward a general storm situated about five hundred miles to the north-west, and has no connection at all with the thunder-storm which is suddenly interjected, as it were, upon the quiet air. Often there are seen two clouds in the south-west and north-west which seem to meet together and produce the storm, but more often the first appearance is that of a great cloud of dust borne upward about three hundred feet, and advancing with great rapidity from the west (sometimes eighty miles per hour). Some of the clouds sprinkle a little rain as the dust-cloud advances, but this is very light. When the storm is very severe, a loud roar is heard like the continuous discharge of electricity which produces a steady instead of intermittent thunder. During this time, lightning-flashes are seen and distant thunder heard. In a few moments, after the dust-cloud has approached nearer and practically with it, the wind suddenly whirls to the west, and blows with great velocity (sometimes eighty miles per hour). Then, in a moment or two more, the lightning and thunder become very intense, and rain falls in torrents. Often the lightning's flash is the signal for a fresh downpour, allowing a few seconds for the fall of the rain from its height. This phenomenon has led to the view, now almost universally accepted, that there is a most intimate relation of cause and effect in this display of electricity and the subsequent rain. Under some circumstances, but invariably in connection with this heavy rain, there fall hail-stones variously measured from the size of a pea to that of hen's eggs, and even larger. In some cases, larger masses, even as great as an elephant, have been reported, but these are due to a mingling or freezing together of many stones in the air or after they reach the earth.

Cold Air.

During the progress of a thunder-storm, and after its front has reached the observer, there is a remarkable cooling of the air. This cooling seems to arise from a downward current in the centre of the storm. It cannot be due to the onrush of a north-westerly wind, for that must come from a warm region, since the thunder-storm has been suddenly interjected into a region of warm southerly winds flowing for hundreds of miles toward the north. This cooling is often very great, and seems to indicate that the air in the centre of the storm is not abnormally heated, as in the case of a general storm, but is very much cooled. The bearing of this upon the generation of the thunder-storm is of great importance, and does not seem to have been sufficiently considered.

Environment.

When the storm passes to the north or south of the observer, there is quite a brisk breeze from it, showing that the motion of the air is from it on at least three sides. Often it is possible to view the storm, in its onward progress, with clear sky overhead, if its border does not reach the zenith of the observer. Under these circumstances, one sees very distinctly up to the highest clouds a steady motion to the east. The rain is seen falling in great sheets, and its front is very distinctly marked. This rain front seems to be an important phenomenon, and has been seen scores of times advancing with a slight lagging at the earth and in the clouds. The appearance impresses one at once as caused by a rapid motion in the middle cloud region, with a lagging at the earth possibly from friction, and in the upper part of the cloud from a less velocity at that point. In no instance has there ever been observed an uprush of air anywhere in this region. These storms go in parallel lines; and as many as four have been seen running one behind the other, the most northerly one in advance. Often it is reported that a storm has gone slightly north of a station, and then turned and come back directly over it; but this is probably an illusion. The second storm has a motion the same as the first, but goes a little farther south. The motion across the country of these storms is about double that of the attending general storm to the north-west.

Probably the most marked characteristic of a thunder-storm, however, is a rise in pressure at its centre. This rise is universally conceded to-day, though its cause is in grave doubt. It has been repeatedly observed in storms where there has been no rain, and hence cannot be due to the cooling of the air by the rain, or to its downward pressure as it falls. How is it possible to account for this rise of pressure in a storm which is itself travelling more than a mile a minute? We have here to consider a phenomenon entirely distinct from a sand-whirl of the desert, which has only a slight progressive motion. There seems to be no doubt whatever that we are to consider here a cause or a condition which is inherent in the storm itself. There can be no upsetting of the equilibrium, no uprush of air just in front of a thunder-storm and nowhere else, which could give such a rise of pressure in so rapidly a moving body of air. We are cer-

tainly dealing here with a *plenum* which moves with the storm, and in fact is the storm itself. It may not be that this is due to a downrush of air-particles from some height; but there is no serious difficulty in assuming that, through electrical action, there is an increased pressure in the centre. It is plain that the foregoing description has a most marked parallelism with that already given of the tornado, and it is virtually admitted that a tornado is simply an extreme development of a thunder-storm.

The attempt to show that while these phenomena are alike in most respects, and yet that in one of the more important factors they are entirely distinct, is most remarkable. We are taught that the origin of both is an unstable equilibrium, in both there is an uprush of air, in both there is a cloud of dust, in both there appear to be two clouds meeting from the north-west and south-west, in both there is a loud roar heard oftentimes, and in both there is a pronounced cooling. They are exactly alike, and produced the same way, but the final result of these actions is to develop two entirely dissimilar and almost opposite conditions. We are told that in a thunder-storm the air starts upward in the centre, has its moisture condensed by expansion, and the resulting precipitation cools the air, increases its density, and finally the diminished pressure at starting gives way to an increased pressure from this change in the density. It must be admitted that this is a reasonable conception, and may be true; but would not this at once destroy the ascending current, and bring the whole action to a standstill? Can we for a moment have both uprushing currents in a storm-centre feeding its energy, side by side with downrushing currents increasing the pressure? It is only necessary to state this contradiction in order to show the absurdity of the hypothesis. This theory strikes at the root of the whole process of liberation of energy in a moist ascending current; but, more than that, if there is such a cooling and subsequent downrush, why should it not act in precisely the same manner in a tornado? How is it possible for this same uprushing current, which starts in exactly the same way in both these conditions, to continue upward in a tornado, to gather energy as it rises, to liberate more and more latent heat, to rush faster and faster, to grow warmer and warmer, and finally to produce the violent tornado with its supposed almost perfect vacuum in the centre, where a half-mile away there is perhaps a thunder-storm causing an increase of pressure? It would seem as though there could hardly be a plainer exposition of the utter futility of all the attempts that modern theorists have made to grapple with this problem than this latest attempt to start the thunder-storm and tornado in the same direction, and finally bring them out, from almost the same conditions, facing in opposite directions, and absolutely dissimilar in their most essential characteristic.

Explosive Effects.

Is it possible for electricity to produce a sudden increase of pressure in a mass of air sufficient to violently rend asunder objects which it strikes? Oftentimes the bark of trees has been driven off; and the usual explanation of this has been, that the heat of the electricity has converted the sap into steam, and this in turn has forced off the bark. This, however, is not satisfactory, for the reason that even a dead and perfectly dry tree has been struck, and scattered over a large field. A remarkable instance of explosive action in a lightning discharge is to be found in *Nature* for May 8, 1890. A tree standing in a rather open field was struck by lightning, and its fragments strewed over two acres of ground. One solid piece weighing five pounds and a half was thrown three hundred and seventy-eight feet. Other *débris* lay two hundred and ten feet in another direction. Small pieces of riven trunk and bark were found thrown in the teeth of the wind and one hundred and eighty feet from the tree. The concussion or increase of pressure smashed six fine glass window-panes in a house not far away. Another very interesting effect was noted in a house that was struck in Washington, D. C., Aug. 23, 1885. In this case the lightning struck the south-west corner of the tin roof on an ell built on the south side of the house, and divided. A portion of the flash passed down an eaves-spout; and at its end, which was two or three feet above the ground, it passed through the air to the damp side of the house, knocking off the plastering on the inside The other portion of the flash passed down between the weather-boarding and the plastering on the east side, shattered one of the upright posts, and appeared to explode off the weather-boarding toward the east, and the plastering toward the west. A woman and her two sons were apparently stunned by the effects.

While such cases have usually been regarded as "freaks" of lightning, yet it would seem that the matter has not been sufficiently studied to enable us to determine just what effect such a discharge would have upon a confined air space. It may be, the apparent bursting of a house in a tornado may be accounted for in this way. An instance has already been given at St. Louis of a rise in pressure, as shown by a barograph, and at the same time a seeming bursting of houses. Hardly a month passes that there is not some discovery regarding this extraordinary force of electricity, and surely we are not in a position to deny that it might not produce a large number of effects now observed in a tornado, such as searing of green leaves, discoloring the trunks of trees, increasing the pressure, exploding houses, depluming fowls, etc. We are told that lightning-flashes are seldom seen in a funnel-cloud. They have been seen there many times. Moreover, it is not at all certain that an ordinary observer would be in a condition to take particular notice of the presence of electricity in a tornado; and, again, the electricity may pass down or up the funnel without a visible flash. The presence of ozone has been often noticed in a tornado where no lightning was seen.

Possibilities of Electric Action.

It has been my purpose for many years to avoid, as much as possible, all speculations in considering air motions and the causes of atmospheric phenomena. This is especially pertinent when we consider electric action in the atmosphere. It is very difficult to believe that electricity has nothing to do with our thunder-storms, and is merely a result, and never a cause. The fact that physicists have never yet been able to account for more than the smallest fraction of atmospheric electricity should lead us to greater diligence in determining its methods. We know from observation that the electric potential is enormously increased as we ascend in the atmosphere. That little or no connection between atmospheric electricity and storms has been observed

by our instruments near the earth is not remarkable, since the earth and air just above it may neutralize all electric action for a hundred feet or more. Our thunder-storms seem to show an enormous storehouse of electricity at five thousand or six thousand feet above the earth; at least, electricity seems to be concentrated there over thousands of square miles during thunder-storm action. We are taught that electricity forms a sort of dual condition, or the electric field is a double one. May not this electric field draw on the sun for its energy? It is believed that light, heat, and electricity are all different manifestations of the same radiant energy. The abundant source of this energy is the sun. Why may not the sun's electricity, oftentimes observed by its direct effect on our magnetic instruments, and more often still indirectly in our auroras, be intercepted by a peculiar condition of the atmosphere or of the earth below, and thus be concentrated in particular localities? Generally this electricity passes through the air to the earth, but must we think that it always does so? May not this electric field or dual condition gradually develop in the atmosphere largely independent of the passage of air-particles through wind or convection currents?

The Electric Field.

For convenience it has been generally considered that particles have a tendency to leave the positive and pass to the negative pole. For example: in the electric arc-light the carbon at the negative pole is built up at the expense of the positive. The velocity of transmission of these carbon particles perhaps cannot be determined, but it must be only a very small fraction of that of electricity, 190,000 miles per second. Is there any inherent improbability in the supposition that in this dual condition in the atmosphere there is a tendency for moisture and possibly dust particles, positively electrified, to pass rather rapidly from the positive pole, or, better, positive portion of the electric field, to the negative portion? We know from observation that during the passage of a high area or clear sky the electric potential, with very few exceptions, becomes markedly positive, while during the fall of rain it is negative. While a thunder-storm is passing, there are most violent fluctuations of the electrometer-needle from negative to positive and back again, as each flash of lightning is noticed. These fluctuations of the needle are perhaps a hundred times as great as under ordinary conditions of rainfall, and take place when the flash is a mile or two away, showing a most extraordinary inductive action upon the atmosphere, and for enormous distances. We have positive evidence of such transmission of moisture-particles by a force entirely distinct from heat, pressure, or any other commonly recognized meteorologic condition. It is known that the moisture in the air is one of the most constant elements we have to deal with. The temperature may rise and fall thirty or forty degrees during the day, and yet the quantity of vapor is in no wise changed. The wind, either in direction or velocity, does not change this moisture. The hiding of the sun's heat or light in no wise affects it. Changes in air-pressure produce no effect in general. As a storm approaches, however, we find a most marked increase in this moisture over thousands of square miles, and this even in a calm. As a storm passes off, the conditions are sharply reversed. The moisture becomes depleted in a most remarkable manner, as though it were actually drawn out of the atmosphere by an invisible agency.

The most remarkable example of such action was observed on Dec. 22, 1889, from a third-story window of a house in Washington. It will be seen that the conditions were not favorable for observing this effect at its best. At 3.11 P.M. there were 4.09 grains per cubic foot, and for more than twenty-four hours previous there had been an abundance of moisture from a storm passing near by. The air was almost a calm, and continued so till nigntfall. At 5.2 P.M., or one hundred and eleven minutes later, there was only 1.04 grain per cubic foot, and this continued as long as observed. To any one who has made determinations of the moisture of the air, and noted its great constancy, frequently for several days, this sudden subtraction must be very extraordinary. If such changes are possible near the earth, and in the centre of a large city with houses for more than a mile on all sides, what may we not expect to take place in the free air, where there are no interferences, and where we know that such forces are acting in far greater intensity than near the earth?

Enormous Fall of Rain.

Just after a thunder-storm or tornado, there are torrents of rain, and in some quarters it is getting to be quite the custom to call such phenomena cloud-bursts. In these cloud-bursts almost an incalculable amount of rain falls, more than a foot having been reported at times. In one case four feet of hail were reported. Just how much territory is covered by such a cloud-burst cannot be told, as the data are not sufficiently numerous, but fifty or sixty square miles may be easily considered. We have already seen that the later theory, which calls for a downrush in the centre of a thunder-storm, effectually disposes of all possibility of this enormous amount of moisture rushing up in the centre and being condensed by expansion. In the case of a tornado, it is incredible that even a thousandth part of this moisture can be carried up in a funnel a few hundred feet in diameter. If we inquire what would be the effect of the ordinary condensation of such a mass of water in the air over such a limited space, we are confronted by an amount of heat set free that is simply appalling. One gallon of rainfall gives out sufficient heat to melt forty-five pounds of cast iron. A very little consideration will show us that it is absolutely impossible, even allowing a current of moist air at any conceivable velocity, for even a small fraction of rain to be precipitated out of such a current. It has already been shown that the latent heat set free would at once re-evaporate the moisture. We seem to be driven to invoke the aid of some other agent than any thus far recognized as cogent in producing our storms. Is it inconceivable that we have to deal here with a negative electric field, which draws to itself with great velocity particles of moisture from regions perhaps for one hundred miles about, when suddenly, upon a discharge of electricity, the potential upon the particles is diminished, and they unite in great abundance and form raindrops? This is a most inviting field for observation. We already have facts enough to make a plausible hypothesis, and, what is very important, we have here an unlimited amount of energy which may be called upon to produce all the effects ever observed.

It is not a little remarkable that the earlier views all ascribed tornadic action to electricity, and it would seem as though the time were not far distant when we would be forced to return to this agent for explaining the phenomena. What are needed are careful experiments in this most enchanting field of research. An attempt has been already made to test the question of the transmittal of moisture through the air by electric action. A Holtz machine was run for fifteen minutes in a rather large room; and most careful measurements of the amount of moisture at the machine and at a point twenty feet away, before and after the machine was in action, showed an increase at the machine. When we consider that it was impossible to measure the moisture contents just at the plate of the machine, and also what an extremely slight charge could by any possibility enter the air from the machine, we can but be surprised that any effect at all was observed. With improved methods of observation by which the exact hygrometric state of the air can be easily and accurately determined, and with very accurate tables of reduction which we now have, all that is required is an observer for investigating these phenomena. The expense for apparatus need not be great.

H. A. HAZEN.

CUSTOMS OF COURTESY.[1]

FEW ceremonial customs have originated in recent times. Their forms, whether now trivial or still important in sociology, are vestiges of the past, and only by anthropologic studies are traceable to their genesis and early form. All authorities, unswayed by a religious or theorizing bias, agree that in the origin of these ceremonies there was nothing designed or intentional; that is, they were not directly invented with definite purposes. A thing is not now and never has been customarily done because it is intrinsically right, but is considered to be right after and because it has been habitually done, whatever its origin or the circumstances in which it prevailed.

The rules of courteous behavior as they now exist are not the immediate effect of deliberate conventions, but are the natural and slow product of the forces gradually developing social life, and they exhibit the laws of evolution with as great distinctness as is demonstrated in the physical realm. Men have not fabricated though they have framed rules for themselves. They have fallen into the customs from which rules were framed, and then by unintended modifications have deviated into novelty and new rules.

To the query "Why do nations and peoples do any thing as a custom?" the optimist answers, "Because it is right;" which assumption yet further confuses the vexed question whether, in the nature of things, there is an absolute right and an absolute wrong; for customs vary even unto opposition in different parts of the world, and not only in different, but in the same, periods of history; so that they cannot all be absolutely right. In matters large and small, vital and trivial, what is esteemed as virtue and merit at one place and time, is condemned at others as vice and crime. Explanation has been attempted on the theory, that, there being distinct races of men, each of them has its idiosyncrasy; indeed, that by primordial decree each of them had the mission to do certain things, and no others. By such theory, fatalism is omnipotent, and all men are marionettes. But this explanation depends upon a conceded classification of men into races, which has failed. A few years ago, school-boys glibly recited the titles of the races of men, with their characteristics; but now students who have devoted long lives to the subject find such classification to be so difficult that no two writers agree. This does not indicate the proposition that there are no distinct races of men; indeed, it is possible that once there were many more races than have ever been recognized, the present condition being one of amalgamation. But the plot of the marionette show becomes confused when there is no agreement about its personages.

The chief justice of a high court lately declared that no race of men was good for any thing which had not believed in only one God, and allowed only one wife. As all the races of men have at some time believed in many gods, and have allowed a plurality of wives, this dictum would condemn all; but it is an example of hysteron proteron, or "the cart before the horse." If the statement had been that polytheism and polygamy were outgrown before the attainment of high culture, it would have been historically true; but as made, it is as inaccurate as to assert that no race is good for any thing in which the men have not always worn trousers,—a useful but recent invention of civilization. Instead of seeking an explanation of customs in race, it is more practical, as well as more scientific, to look for it in habitat and history; i.e., in environment.

An apparent exception occurs in the arbitrary edicts of fashion, styled very properly by Borachio as "a deformed thief;" but a distinction may readily be made between custom and fashion. Fashion is imitation and transitory. It is most commonly noticed in details of dress or ornament designed by some influential person to conceal a defect or display a beauty; sometimes, however, in latter days, by a conspiracy of manufacturers, tailors, or milliners. With the cessation of the special influence, the imitation gradually declines, unless, indeed, genuine merits are discerned in the invention, in which case it is assimilated through the vital catalysine faculty. The method of human progress is empirical. The good and useful, when ascertained by experiment, are retained for further improvement throughout the ages, while the nocuous or useless are sooner or later rejected.

The views submitted dissent, though meekly, from some details in the work of that great writer and thinker, Herbert Spencer. No one can deny his comprehensive grasp of intellect, his brilliance of style, and his wealth of illustration, but more especially the wonderful and far reaching suggestiveness by which he has awakened and guided modern thought. Yet he is more beneficent as an educator of the mind than as an instructor in facts. In particular, his most admiring student must lament the Zoroastrian phantasy or dual antagonism of good and evil that mystifies his principles of sociology. To him militancy is Ahriman, and industrialism is Ormuzd, and their conflict is forced to explain all the myriad problems of human life. But the known causes and effects are too numerous and diverse to be disposed of by one universal solvent. The complex knots must be patiently untied, and cannot be severed by the rusty sword of a vamped and varnished Parsee dualism. Nor does history confirm this prosopopœia of good and evil. Industrialism began very early, and among the most cultured nations is now in a high state of development; yet it exhibits within itself strife and turmoil, selfishness and cruelty, equal to all the similar crimes ever charged against militancy. The latter has by no means passed away, though the human race has surely advanced. In fact, an evolutionary advance is manifest in militancy itself parallel with that seen in other lines of thought and action. Militancy, therefore, is not the cacodemon by whose overthrow alone the world has grown better.

The verbal forms of salutation may be divided into (1) those of a purely religious character, (2) those equivalent to a prayer for the health and temporal good of the person saluted, (3) those simply wishing health and prosperity without direct invocation of a deity, and (4) those expressing personal or official affection or respect.

1. The Israelites, both in meeting and parting, used a word meaning "blessing," and the person addressed was thereby commended to God. The expressions "Blessed be thou of the Lord!" and "The Lord be with thee!" are traditional.

The Arabian often says, "God grant thee his favors!" also "Thank God! how are you?" and the Turk, "My prayers are for thee," or "Forget me not in thy prayers." In Poland a visitor to a house will cry out, "The Lord be praised!" to which the hostess will answer, "World without end, amen!" The "sweet girl

[1] Abstract of the leading article in the American Anthropologist for July, 1890, by Garrick Mallery.