

LETTERS TO THE EDITOR.

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The editor will be glad to publish any queries consonant with the character of the journal.

Tornadoes: Fact vs. Fiction.

THERE is no subject in meteorology of more absorbing interest than this. As our knowledge of the environment of tornadoes increases, there must necessarily be modifications in our views of their origin. One of the more recent and most significant of these changes has been the transference of the cool northerly wind, meeting the warm south wind, from the earth's surface to the upper regions, where it is said to overflow the lower current, and produce an unstable equilibrium in the atmosphere. It would seem as though no subject can demand, more strongly than this, a solid substratum of fact; and yet, strange to say, the theories and speculations about these terrible visitors have been far more extensive than the facts. This seems a favorable time to state a few of the more prominent facts and seeming fictions. The facts are these:—

1. It has been well said that the most important recent development has been the fact that tornadoes occur, not at the centre of a general storm, but about four hundred miles to the south-east. This fact was known fifteen years ago, but was first strongly emphasized in March, 1884.

2. All currents in this region, even up to a great height, are from the south before the tornado, as is well known from observations of the upper clouds.

3. The tornado invariably moves to the north-east; and if, as some believe, it takes its motion in the upper current, that must be from the south-west, and cannot be from the north even after the tornado.

4. The pressure rises in a tornado, as has been observed a few times in it, and it invariably rises at the centre of a thunder-storm, which frequently develops into a tornado.

5. That some other force than a violent gale blowing into a partial vacuum is concerned in the destruction, is well shown by the fact, that of two free barrels side by side, one of which was empty and the other full, the former was left undisturbed, while the other was completely obliterated. Fowls have been stripped of their feathers, and people deprived of their clothing, which could not be brought to pass by the most violent gale.

6. The tornado is extremely sudden, and, advancing without any warning, it interjects itself into a region of gentle southerly winds. After it has passed, the southerly wind almost at once again predominates. The whole appearance is as though a disturbance, largely having its own source of energy, had suddenly projected itself into a quiet air, and passed on without bringing about any but a momentary change.

7. Its velocity is nearly double that of the accompanying general storm.

8. Numerous thunder and hail storms are an invariable accompaniment.

A few fictions are the following:—

1. Professor Ferrel states on p. 327, "Recent Advances in Meteorology," that in the tornado there is an unstable equilibrium due to "the large vertical gradient of temperature decreasing with increase of altitude."

2. Mr. Finley, in *Science* of Feb. 1, thinks that this same condition must be found, not in the tornado, but in the region just around it.

3. This abnormal decrease of temperature is due to cold air overrunning warm. This is really an impossible condition, since the denser cool air must always under-run that which is lighter and warmer. That a most extraordinary decrease of temperature and most extreme unstable equilibrium, possibly five hundred times as great as can ever occur under natural conditions, does not produce a destructive whirl, advancing scores of miles from its origin, is well shown by the seas of fire extending many square miles in forest clearings. Here there is a temperature at least 1000° higher than that of the air two or three hundred feet above it. There are

occasional whirls set up over such a fire, but they are short-lived, and extend only to its edge.

4. There is a violent uprush of air at the tornado centre. As we have just seen, the tornado is not at the storm-centre, but four hundred miles to the south-east, where there is no rising tendency in the air.

5. There is a uniform flow of northerly upper currents over an extended region, and tornadoes are produced at spots one hundred miles apart by the breaking-through of the warm lower air.

6. The tornado, in its onward motion dipping here and there for one hundred miles and more, has its energy kept up by a continual upsetting of the equilibrium, conveniently occurring just in front of it exactly at the moment of its advance, and nowhere else. These latter certainly have no facts to sustain them, and must be regarded as impossible or highly visionary till observations in the cloud region give still further facts. Until these facts are had, it is unsafe to theorize.

H. A. HAZEN.

Washington, Feb. 4.

A Deadly Gas-Spring in the Yellowstone Park.

THE familiar fable of the upas-tree, living in a valley of death wherein all life was killed by its deadly exhalations and the ground was strewn with the bones of its victims, has been proven, like many a traveller's tale, to be a highly colored and exaggerated account of a natural phenomenon. The upas-tree is now well known to have poisonous sap, but not poisonous vapors. But the story survives in the accounts given of the Death Valley of Java, which it was long believed no traveller could cross, "wherein every living being which penetrated the valley falls down dead, and the soil is covered with the carcasses of tigers, deer, birds, and even the bones of men, all killed by the abundant exhalations of carbonic-acid gas, with which the bottom of the valley is filled." Such is the description given by Lyell¹ of this famous valley; while another locality is described as a place where "the sulphurous exhalations have killed tigers, birds, and innumerable insects, and the soft parts of these animals are perfectly preserved, while the bones are eroded and entirely destroyed. The researches of Junghuhn² have shown that these accounts are much exaggerated, the "valley of death" being a funnel-shaped depression but one hundred feet in diameter, instead of a valley half a mile across. In the bottom of this depression there is a hole about fifteen feet in diameter, from which gaseous emanations are given out, which at times accumulate to a depth sufficient to envelop and suffocate animals on the bottom of the hollow. Repeated visits by Junghuhn, extending over a period of twelve years, showed that the amount of gas varied greatly from time to time, but rarely ever rose over two feet and a half above the bottom. At the time of his earlier visit, he found the body of a Javanese native in the depression, but experienced no difficulty or oppression while there himself. This same body was still undecomposed, owing to the preservative effect of the layer of gas, when he repeated his visit eighteen months later. The only other remains seen during his subsequent visits were the carcasses of six swine which were decomposed and putrid. At this time the absence of the gas was shown by the presence of a crow feeding upon the dead bodies.

Though thus shorn of much of its former glory, this Pakaraman, or poison-hole, is the largest and most dangerous of the gas-springs or mofettes of Java, and indeed of the world, and really deserves the title of a natural death-trap. Though such emanations are common in all volcanic regions, this has been the only place known where the gases have accumulated, and caused the death of the larger animals.

In the Yellowstone National Park, now so well known as the wonderland of America, there is a place equalling this famous death valley, and where the gaseous exhalations have proved fatal to numerous bear, elk, and many smaller animals.

This place, to which the appropriate name of "Death Gulch" is given, was discovered by the writer during the past summer (1888), while making a geological examination of the region for Mr. Arnold Hague, the geologist in charge of the survey of the park. It is situated in the extreme north-eastern portion of this reservation, a

¹ Principles of Geology, 1878, i. p. 590.

² Java Seine Gestalt, etc., German translation by Hass Karl, ii. p. 202.

short distance south of the mail-route, which, leaving Lamar River, follows up Soda Butte Creek to the mining-camp of Cooke City. In this region the lavas which fill the ancient basin of the park rest upon the flanks of mountains formed of fragmentary volcanic ejecta, the tertiary andesitic breccias, which rest in turn upon nearly horizontal paleozoic strata; while the hydrothermal forces, which are represented by the geysers and hot springs of the central portion of the park, where the lava-sheet is thicker, show but feeble manifestations of their energy in the almost extinct hot-spring areas of Soda Butte, Lamar River, Cache Creek, and Miller Creek. Although hot water no longer flows from the vents of these areas, the deposits of travertine, sinter, and decomposed rock, attest the former presence of thermal springs. Gaseous emanations are now given off, however, in considerable volume, producing extensive alteration in the adjacent rocks, and giving rise to sulphurous deposits.

It is at one of these places that the fatal ravine is found. Situated on Cache Creek, but two miles above its confluence with Lamar River, it is easily reached by a horseback ride of some five miles from the mail station of Soda Butte. The region is, however, rarely visited; for hunting is forbidden in the park, while the place has not been known to present any attraction for the few visitors who pass near it on their way to the well-known Fossil Forests and the weird scenery of the Hoodoo basin.

An old elk-trail, which runs along the north bank of Cache Creek, affords easy travelling, and leads to a little opening in the pine-forest bordering on the stream. In the centre of the meadow is a shallow depression, once the bed of a hot-spring pool, now dry, and covered with an efflorescence of salt, making it attractive to the elk and other game of the region as a "lick." The banks of the creek opposite this meadow and below it are covered with the ancient hot-spring deposits, which are very dense and hard, and at the borders of the stream have been polished by the action of the water until the surface shines like glass. A hot-spring cone half washed away by the creek, and a mound of altered travertine on the opposite bank, show the character of the ancient hot-spring water, the rippled surface of the deposit being exactly like that of the beautiful terraces and slopes of the Mammoth Hot Springs. At present, however, the only thermal action is the emission of a little tepid sulphurous water at the edge of the stream. On the other hand, the gaseous emanations are very striking and abundant.

In the middle of the creek, which here forms a deep pool about thirty feet across, bordered by the polished calcite already mentioned, the water boils up furiously at several places. This water is, however, quite cold; and the "boiling" is caused by the very copious emission of gas, mainly, no doubt, carbonic acid, though containing some sulphuretted hydrogen, since its smell is quite noticeable, and the water is slightly turbid with particles of sulphur, which also coat the sides and bottom of the pool. Rising through the water of the creek, the great amount of gas given off at this place is easily appreciated, but equally copious emanations may occur from the deposits and old vents near by, which, being invisible, remain unnoticed.

Above these deposits of altered and crystalline travertine, the creek cuts into a bank of sulphur and gravel cemented by this material, and a few yards beyond is the debouchure of a small lateral gulley coming down from the mountain-side. In its bottom is a small stream of clear and cold water, sour with sulphuric acid, and flowing down a narrow and steep channel cut in beds of dark gray volcanic tuff. Ascending this gulch, the sides, closing together, become very steep slopes of white decomposed rock, the silicious residue formed by the decomposition of the rocks by acid vapors or waters. The only springs now flowing are small oozes of water issuing from the base of these slopes, or from the channel-bed, and forming a thick, creamy, white deposit about the vents, and covering the stream-bed. This deposit consists largely of sulphate of alumina. The slopes show local areas where sulphur has been deposited by the oxidation of sulphurous vapors, but no extinct hot-spring vents were found. About one hundred and fifty feet above the main stream, these oozing springs of acid water cease; but the character of the gulch remains the same. The odor of sulphur now becomes stronger, though producing no other effect than a

slight irritation of the lungs. The gulch ends, or rather begins, in a "scoop" or basin about two hundred and fifty feet above Cache Creek; and just below this we found the fresh body of a large bear, a silver-tip grisly, with the remains of a companion in an advanced state of decomposition above him. Near by were the skeletons of four more bears, with the bones of an elk a yard or two above; while in the bottom of the pocket were the fresh remains of several squirrels, rock-hares, and other small animals, besides numerous dead butterflies and insects. The body of the grisly was carefully examined for bullet-holes or other marks of injury, but showed no traces of violence, the only indication being a few drops of blood under the nose. It was evident that he had met his death but a short time before, as the carcass was still perfectly fresh, though offensive enough at the time of a later visit. The remains of a cinnamon bear just above and alongside of this were in an advanced state of decomposition, while the other skeletons were almost denuded of flesh, though the claws and much of the hair remained. It was apparent that these animals, as well as the squirrels and insects, had not met their death by violence, but had been asphyxiated by the irrespirable gas given off in the gulch. The hollows were tested for carbonic-acid gas with lighted tapers without proving its presence; but the strong smell of sulphur, and a choking sensation of the lungs, indicated the presence of noxious gases, while the strong wind prevailing at the time, together with the open nature of the ravine, must have caused a rapid diffusion of the vapors.

This place differs, therefore, very materially from the famous Death Valley of Java and similar places in being simply a V-shaped trench, not over seventy-five feet deep, cut in the mountain-slope, and not a hollow or cave. That the gas at times accumulates in the pocket at the head of the gulch, is, however, proven by the dead squirrels, etc., found on its bottom. It is not probable, however, that the gas ever accumulates here to a considerable depth, owing to the open nature of the place and the fact that the gulch draining it would carry off the gas, which would, from its density, tend to flow down the ravine. This offers an explanation of the death of the bears whose remains occur, not in this basin, but where it narrows to form the ravine; for it is here that the layer of gas would be deepest, and has proven sufficient to suffocate the first bear, who was probably attracted by the remains of the elk, or perhaps of the smaller victims of the invisible gas; and he, in turn, has doubtless served as bait for others who have in turn succumbed. Though the gulch has doubtless served as a death-trap for a very long period of time, these skeletons and bodies must be the remains of only the most recent victims; for the ravine is so narrow and the fall so great, that the channel must be cleared out every few years, if not annually. The change wrought by the water during a single rain-storm, which occurred in the interval between my first and second visits, was so considerable that it seems probable that the floods of early spring, when the snows are melting under the hot sun of this region, must be powerful enough to wash every thing down to the cone of *débris* at the mouth of the gulch.

Gaseous emanations are very frequent in volcanic countries, and may be either temporary or permanent. The former are, as is well known, particularly abundant after volcanic eruptions. The gases emitted from fissures in the flanks of Vesuvius are said to have killed thousands of hares and pheasants, and whole herds of cattle have been suffocated by volcanic gas given off near Quito. The permanent emissions of gas, such as the mofettes of Italy, the Laacher See, and the Auvergne, remain unchanged, however, for centuries. Where carbonic-acid gas is evolved from a fairly uniform surface, it is quickly diffused into the atmosphere upon the slightest movement of the air; but the case is quite different when the gas is emitted in caves or hollows in the ground. In such places it accumulates, because of its density and slow diffusion, until the hollows are filled to the brim, any excess being quickly diffused as from a level surface. Small hollows of this kind occur in the travertine deposits of the Mammoth Hot Springs of the park, and near the Hot Lakes of the Lower Geyser basin. In these places, small birds, mice, etc., attracted by the warmth of the vapors, or the dead insects, are often suffocated by the gases. Such hollows resemble the mofettes of the Laacher See in Germany, where

dead mice and birds are always found, and are common in other regions as well. The well-known Grotto del Cano, near Naples, is the most familiar example of such accumulations of carbonic-acid gas; and visitors are frequently entertained by the asphyxiation of a poor dog, while the guide, whose head rises above the gas, is not affected by it. Death Gulch is, however, without a peer as a natural bear-trap, and may well be added to the list of the wonders of the Yellowstone Park.

WALTER H. WEED.

U. S. Geol. Surv., Washington, Jan. 30.

A New Method for the Microscopical Examination of Water.

IN making microscopical¹ examinations of potable waters, it is entirely impracticable, on account of their relative purity, to proceed directly. Repeated examinations of random samples might yield absolutely nothing, although filtration of a few cubic centimetres through a fine cloth might show that in the same water there were abundant microscopic forms.

The importance of being able to ascertain the presence of these microscopic organisms, and to determine their number and species in any given sample of water, is self-evident. It is important, not only from a purely scientific, but also from a sanitary, point of view, to know precisely what is contained in drinking-water. Again: large manufacturing interests are dependent upon the purity of the water supplied to them through filters or otherwise, while many large towns depend upon the efficiency of filters for the purity of their water-supply. A microscopical examination of the water before and after filtration shows very clearly the actual work which the filter accomplishes, in a way that it is impossible for chemical analyses to do. From a scientific and sanitary point of view, microscopical examinations are accordingly of great value both as a means for the study of the organisms themselves, and of the influences of changes in the water upon their growth, life, and death, as well as the counter effects produced upon the water by them. For making such examinations there have been hitherto, so far as I know, but two methods employed. One of these is that proposed by Dr. J. D. McDonald in his "Guide to Microscopical Examination of Water" (J. & A. Churchill, London, 1883). In this method the sample to be examined is put into a tall glass cylinder, at the bottom of which is a watch-glass suspended by a platinum wire. This is allowed to stand for forty-eight hours, in order that the matters held in suspension may settle into the watch-glass at the bottom. The upper water is then siphoned off, and the contents of the watch-glass examined under the microscope.

The other method, the origin of which I do not know, is used at present by the Massachusetts State Board of Health. In this method a given quantity of water is passed through a fine linen or cotton cloth tied to the lower end of a funnel. After the water has passed through it, the cloth is removed, and cautiously reversed over the end of a glass tube, the numerous objects which have been caught upon the cloth being now upon the outside. A slide is then placed under the cloth, and a puff of air blown through the tube. The moisture contained in the cloth collects in a drop, which falls upon the slide, carrying with it theoretically the materials filtered out of the water. The slide is then examined under the microscope, and the organisms obtained counted. Both these methods are open to very serious objections, and are so crude that no fair estimates of the number of organisms contained in a given sample of water can be formed. In the case of the first method, I have found that by no means all of the microscopic organisms settle to the bottom, even when the water is left standing a much longer time than forty-eight hours, as there are many which have about the same specific gravity as water, and consequently do not settle. This source of error becomes greater in proportion as the water to be examined becomes purer. In the case of ordinary drinking-water, the sediment is very inconsiderable, although there are large numbers of organisms held in suspension. Under ordinary circumstances, water left standing in this way gives an excellent opportunity for the organisms present to increase. Especially is this the case with filtered water, where the increase is surprisingly rapid. From this it is plain that the sediment in the watch-glass does not represent what was originally in the water, but only

a small part of that amount plus a part of the increase which has since taken place. In the second method, if the cloth be examined microscopically after presumably all the microscopic organisms have been removed, it will often be found that a very large number are stuck in the meshes of the cloth.

For these two methods I have substituted one which, although far from perfect, gives much better results. I have now been using it for four months in making microscopical examinations of water for the city of Boston.

The new method is as follows. A known quantity of water (I have found 100 cubic centimetres a convenient unit) is put into a funnel in the tube of which is half an inch in depth of sand (24 to 30 grains to the inch). The sand is held in place by a stop made of a roll of brass wire gauze, which gives free passage to the water, while it holds the sand in place. Through this the water is filtered, the sand holding back the microscopic forms. The experiments which I have tried, to test whether all the organisms are removed or not, have proven conclusively the efficiency of the sand in holding back all the microscopic organisms in the water. After all the water has passed through, the stop is removed, and one cubic centimetre of distilled water (the water which has just been filtered will answer as well) is thrown into the funnel by means of a pipette. This washes the sides of the funnel, and carries the sand with it down into a watch-glass which is held underneath to receive it. On falling into the watch-glass, the grains of sand separate and sink to the bottom, leaving the lighter organisms which have been caught between them mostly suspended in the water. By stirring this wash-water a more even distribution of the organisms is obtained, and, if any have been carried to the bottom by the falling sand, they are liberated; so that if the wash-water be poured off, and the sand examined under the microscope, it will be found that there are no more organisms among it than might be expected. Some of the water standing above the sand is immediately transferred to a slide containing a chamber the capacity of which is one cubic millimetre. All the microscopic organisms contained in this chamber are then counted under the microscope, and from the result the total number of organisms in the original sample is computed. I have found this cubic millimetre surprisingly representative of the whole mass of the wash-water, as far as the numbers go, although, as would naturally be expected, the species vary largely in different samples.

This method, as the first which can fairly be called quantitative, opens up a new field, having wide and practical applications. It is to be hoped that microscopical examinations may hereafter take their proper place alongside of bacteriological and chemical analyses, to which they must form important adjuncts.

A. L. KEAN.

Mass. Inst. Technol., Boston, Feb. 1.

Triple Births in the Human Race.

I WAS much interested in the note published in *Science* of Feb. 8, upon triple births in the human race, and I beg to direct your attention to a curious case to be found among the records of Middleboro [Mass.], in which triple births occurred in two successive generations of the same family.

Elisha Vaughan married Joanna Morton, daughter of John Morton of Middleboro.

Children of Elisha and Joanna Vaughan.

Hinksman	.....	b. 1708, Jan. 11.
Mercy	}	.....b. 1711, July 12.
Sarah		
Thankful		
Thomas	.....	b. 1714, Dec. 1.
Hannah	.....	b. 1717, Oct. 25.

Children of Hinksman and Desire Vaughan.

Hannah	.....	b. 1733, April 29.
Elisha	}	.....b. 1735, June 1.
Abraham		
Ebenezer		
Abigail	.....	b. 1737, March 21.

The town and church records in Middleboro comment upon the curious reversal of the sexes in the two generations.

ALEXANDER GRAHAM BELL.

Washington, Feb. 12.

¹ It is convenient to designate by "microscopic" all forms of life visible only by means of the microscope, exclusive of the bacteria.