portion is small. Since, now, the heat of combustion of cellulose is the same as that of starch, according to von Rechenberg's determinations,[1] the difference in the nutritive value of the two must be measured by the heat of combustion of the marsh-gas and hydrogen evolved.

The well-known experiments of Henneberg and Stohmann on the respiration of sheep showed no considerable excretion of either hydrogen or marsh-gas. In one of them, for example, the animal ate per day 1,216 grams of hay, and excreted 1.5 grams of marsh-gas. Not having at hand the original account of the experiment, we will assume that the hay contained only twenty-five per cent of crude fibre, of which one-half was digested. This amounts to 152 grams per day. This quantity of cellulose, if oxidized to carbonic acid and water, would yield 676,-704 cal.[2] From this we have to deduct the amount of heat carried off in 1.5 grams of marsh-gas, which, according to Favre and Silbermann, amounts to 19,595 cal. There remain 657,109 cal., representing the worth of the 152 grams of cellulose to the animal. The same weight of starch, if completely oxidized, would yield 680,808 cal.: in other words, the cellulose set free in the body of the animal ninety-six and a half per cent of the energy which the same weight of starch would have done.

Naturally these calculations are not exact; but they serve to show, that, if the heat liberated during the fermentation of the cellulose is of use to the animal, the nutritive value of cellulose does not fall so much below that of other carbohydrates as some are inclined to believe. H. P. ARMSBY.

IS THE RAINFALL OF KANSAS INCREASING?[3]

THIRTY years ago the territory of Kansas was not occupied by the white man, and, if we except a few acres cultivated by the Delaware Indians, no portion of her soil had been turned up by the plough. Her entire area was included within the vast and almost unknown region of the 'treeless plains' and the 'great American desert.' During that brief intervening period, more than a million people, chiefly of the agricultural class, have taken possession of her domain, and have already brought her to the very front rank of the states of the Union in the extent and value of her agricultural products. History affords no other instance of the permanent occupation of so extensive an area, previously unoccupied by man, by so large an agricultural population, in so short a space of time. Here, certainly, if human agency could anywhere affect climate, would such an effect be produced. Here, assuredly, if settlement ever increases rainfall, will such increase be most marked and most unmistakable. That such increase has actually taken place, I believe to be established beyond a doubt. It is a circumstance peculiarly favorable to the determination of the point in question, that, although the general settlement of Kansas by cultivators of the soil is of such recent date, reliable observations upon the rainfall had been made at the military posts upon the eastern borders for a sufficient period to make possible a satisfactory comparison between the rainfall before settlement and after settlement. The records at Fort Leavenworth cover the longest period, and enable us to compare the nineteen years immediately preceding the occupation of Kansas by white settlers with the nineteen years immediately following such occupation. During the first period the average rainfall was 30.96 inches; during the second period it was 36.21 inches; giving an average increase of 5.21 inches per annum, — an increase of nearly twenty per cent. The Fort Leavenworth records cover so long a period of time (nearly forty years), that the increased average of the second half of the period cannot be attributed to a mere 'accidental variation.' In the issue of *Science* for April 18, 1884, it is stated that "the supposed increase in the rainfall in the dry region beyond the Mississippi is not borne out by the returns of the signal-service." But the records of the signal-service upon which this statement was based include a period of only twelve years of observation (from 1871 to 1882), which is undoubtedly too short a period for either establishing or disproving the fact of a 'secular' variation.

But the fact of an increased Kansas rainfall does not rest entirely upon the Fort Leavenworth observations. There are other stations in Kansas whose records cover a much longer period than that of the longest established regular station of the signal-service. There are the twenty years' records of the U. S. military post at Fort Riley, the twenty four years' records of the State agricultural college at Manhattan, and the seventeen years' records of the State university at Lawrence. If these several periods of observation be divided into two equal parts, in each case it is found that the average rainfall of the second half is notably greater than that of the first half. At Fort Riley the increase amounts to 3.05 inches per annum, and at Manhattan to 5.61 inches per annum, and at Lawrence to 3.06 inches per annum. Expressed in per cent, the rainfall of these three stations has increased in the second half of each period of observation, at Fort Riley, thirteen per cent; at Manhattan, twenty per cent; and at Lawrence, over nine per cent. If the increased rainfall could be shown by the records of a single station only, or if the several stations with sufficiently long periods of observation exhibited discordant results (some indicating a decrease, while others indicate an increase), or if even a single station indicated a diminished rainfall, the fact of a general increase would lack satisfactory demonstration. But the entire agreement of the four stations whose records have been used in a discussion of this question seems to establish beyond doubt the fact of an increased rainfall in the eastern half of Kansas.

There can be no reasonable doubt that the general

[1] *Journ. prakt. chem.*, n. f., xxii. 1 and 223.

[2] 1 cal. = the amount of heat required to raise the temperature of 1 gram of water 1° C.

[3] Lecture before the Kansas academy of sciences, Nov. 25, by Prof. F. H. SNOW.

settlement of the western portion of Kansas will have a similar effect upon its rainfall; but it is not reasonable to expect that western Kansas will ever boast of a rainfall equal to that of eastern Kansas. So long as the eastern half of the state remains to the east of the meridian forming the western boundary of the Gulf of Mexico, the south winds will cause it to receive much larger supplies of vapor, for condensation into rain, than will be received by the western half of the state, which lies beyond the immediate track of the vapor-laden winds. It must be remembered that climatic changes are exceedingly gradual; and a rain deficiency or excess for a single year, or for two or three years in succession, must not be considered as invalidating the law of general averages. Neither should the fact that the rainfall, upon the whole, is increasing, induce settlers to break land in the western third of Kansas with the expectation of successfully raising the same crops as in eastern Kansas. Such settlers will surely be disappointed. It is even doubtful if paying crops of any kind can ever be continuously produced in that region. With an average before settlement of about fifteen inches per annum, the same percentage of increase as has been made in eastern Kansas in thirty years would give an annual amount of less than eighteen inches, — a quantity entirely inadequate to maintain successful agriculture.

AMERICAN SOCIETY FOR PSYCHICAL RESEARCH.

AT a meeting held in Boston, Sept 23, to consider the advisability of the formation of a society for psychical research in America, the whole matter was placed in the hands of a committee of nine, consisting of Dr. G. Stanley Hall of Johns Hopkins university; Prof. E. C. Pickering, director of the Harvard college observatory; Dr. H. P. Bowditch and Dr. C. S. Minot, of the Harvard medical school; Mr. S. H. Scudder, president, and Professor Alpheus Hyatt, curator, of the Boston society of natural history; Professor William James of Harvard college; Professor William Watson of Boston; and Mr. N. D. C. Hodges of Cambridge. This committee held a number of meetings during the months of October and November, and issued an invitation to a number of scientific men throughout the country to join in a society under a constitution upon which they had decided. To this invitation there were favorable replies from about eighty.

The first meeting of the society was held in Boston on the 18th of December. Under the constitution the conduct of the society is placed in the hands of a council of twenty-one, seven to be chosen each year, to hold office three years. Of this council, there were elected at this first meeting, fifteen: Prof. G. Stanley Hall, Prof. George S. Fullerton, Dr. William James, Prof. E. C. Pickering, for three years; Professor Simon Newcomb, Dr. C. S. Minot, Dr. H. P. Bowditch, Mr. N. D. C. Hodges, for two years; Prof. George F. Barker, Mr. S. H. Scudder, Rev. C. C. Everett, Mr. Morefield Storey, Professor John Trowbridge, Professor William Watson, Professor Alpheus Hyatt, for one year.

The sub-committee on work made an informal report, and has since issued a circular to members, asking for volunteers on the investigating committees and for information regarding promising subjects for investigation, such as mediums, mind-readers, mesmeric subjects, etc.

The society adjourned to meet on the ninth day of January.

THE NATURAL BRIDGE OF VIRGINIA.[1]

DURING a recent trip to Virginia (Oct. 2 to 6) I visited the Natural Bridge ; and although in possession of the guide-book of the locality (edition of 1884), and the admirable articles published by Major Jed. Hotchkiss in *The Virginias*, I failed to obtain certain information relating to the bridge, which would be of special interest to the topographer and geologist. Some of the observations which I made, although of a general character, may be of interest.

The bridge is undoubtedly the remnant of the top of a cave which was probably formed long before the Luray cavern, which is excavated out of the same lower Silurian limestone formation. The bridge seems to be located in the centre of a gentle basin or synclinal in the strata, which may account for the roof of the ancient cavern being left at this special point. The height of the bridge has evidently been much augmented by a lowering of the bed of Cedar Creek through the agency of chemical and mechanical erosion after the destruction of the original cavern. The height of the original cavity, at the point where the bridge now exists, was in consequence very much less than the present height of the intrados of the bridge-arch.

The elevation of the railroad-track at Natural-Bridge station, on the Shenandoah valley railroad, is seven hundred and sixty feet above ocean-level; and the elevation of Cedar Creek, under the north face of the bridge-arch, is nine hundred and fifteen feet, as determined by two independent lines of barometric levels which I ran between the railroad-station and the bridge.

The height of the crown of the arch on the north side, at the 'Lookout Point,' is one hundred and eighty-eight feet above the creek, measured with a cotton twine, which was the only line of the required length which could be obtained. The same height measured by the barometer (Short & Mason aluminum aneroid) was determined as one hundred and eighty-six feet. Neither of these methods of measurement is sufficiently exact to permit of a final statement, but the results are of interest in the absence of more definite data.

The thickness of the arch under the crown on the north side is approximately forty-six feet, and on the south side thirty-six feet.

[1] Read before the American philosophical society, Oct. 17, 1884, by CHARLES A. ASHBURNER.