unmistakably with the disturbance in the rocks caused by their upheaval into arches, but the crucial test was yet to be made in the actual location of good gas territory on this theory. During the last two years, I have submitted it to all manner of tests, both in locating and condemning gas territory, and the general result has been to confirm the anticlinal theory beyond a reasonable doubt.

But while we can state with confidence that all great gas-wells are found on the anticlinal axes, the converse of this is not true; viz., that great gas-wells may be found on all anticlinals. In a theory of this kind the limitations become quite as important as, or even more so than, the theory itself; and hence I have given considerable thought to this side of the question, having formulated them into three or four general rules (which include practically all the limitations known to me, up to the present time, that should be placed on the statement that large gas-wells may be obtained on anticlinal folds), as follows: —

(*a*) The arch in the rocks must be one of considerable magnitude; (*b*) A coarse or porous sandstone of considerable thickness, or, if a fine-grained rock, one that would have extensive fissures, and thus in either case rendered capable of acting as a reservoir for the gas, must underlie the surface at a depth of several hundred feet (five hundred to twenty-five hundred feet); (*c*) Probably very few or none of the grand arches along mountain ranges will be found holding gas in large quantity, since in such cases the disturbance of the stratification has been so profound that all the natural gas generated in the past would long ago have escaped into the air through fissures that traverse all the beds. Another limitation might possibly be added, which would confine the area where great gas-flows may be obtained to those underlaid by a considerable thickness of bituminous shale.

Very fair gas-wells may also be obtained for a considerable distance down the slope from the crest of the anticlinals, provided the dip be sufficiently rapid, and especially if it be irregular, or interrupted with slight crumples. And even in regions where there are no well-marked anticlinals, if the dip be somewhat rapid and irregular, rather large gas-wells may occasionally be found, if all other conditions are favorable.

The reason why natural gas should collect under the arches of the rocks is sufficiently plain, from a consideration of its volatile nature. Then, too, the extensive fissuring of the rock, which appears necessary to form a capacious reservoir for a large gas-well, would take place most readily along the anticlinals where the tension in bending would be greatest.

The geological horizon that furnishes the best gas-reservoir in western Pennsylvania seems to be identical with the first Venango oil-sand, and hence is one of the Catskill conglomerates. This is the gas-rock at Murraysville, Tarentum, Washington, Wellsburg, and many other points. Some large gas-wells have been obtained in the subcarboniferous sandstone (Pocono), however, and others down in the third Venango oil-sand (Chemung).

In Ohio, gas-flows of considerable size have been obtained deep down in the Cincinnati limestone, while in West Virginia they have been found in the Pottsville conglomerate: hence natural gas, like oil, has a wide range through the geological column, though it is a significant fact that it is most abundant above the black slates of the Devonian.

Of the composition, probable origin, extent of gas territory in the country, and many other interesting points connected with natural gas, the necessary brevity of this article forbids any mention; but the writer has in preparation a more general paper on the subject, in which these and kindred questions will be discussed with more detail. I. C. White.

THE EFFECTS OF COLD ON LIVING ORGANISMS.

Mr. Coleman and Professor McKendrick have made some remarkable experiments [1] on the effect of low temperatures on living organisms, particularly microbes, using for this purpose the cold-air machinery invented by Mr. Coleman, which, in its ordinary working, delivers streams of air cooled to about 80° below zero (— 63° C.), but by certain modifications as low temperatures can be secured as have yet been produced in physical researches. The actual temperatures in these experiments were taken by an absolute alcohol thermometer, made by Negretti and Zambra, and checked by a special air thermometer devised by Mr. Coleman.

The experiments consisted in exposing for hours to low temperatures putrescible substances in hermetically sealed tins or bottles, or in flasks plugged with cotton wool. The tins or flasks were then allowed to thaw, and were kept in a warm room, the mean temperature of which was about 80° F. They were then opened, and the contents submitted to microscopical examination. The general result may be stated thus: The vitality of micro-organisms cannot be destroyed by prolonged exposure to extreme cold. It is clear, therefore, that any hope of preserving meat by permanently sterilizing it by cold must be

[1] Proc. Philos. soc. Glasgow, March 4, 1885.

abandoned; for the microbes, which are the agents of putrefaction, survive the exposure.

Some of the experiments on which this conclusion rests are briefly described. Meat in tins, exposed to — 63° C. for six hours, underwent (after thawing) putrefaction with generation of gases. Trials with fresh urine showed that freezing at very low temperatures delayed the appearance of the alkaline fermentation, but a temperature of — 63° C. for eight hours did not sterilize the urine. Samples of fresh milk exposed to temperatures of from zero to — 80° F. for eight hours, curdled, and showed the well-known Bacterium lactis; and, so far as could be observed, freezing did not delay the process after the flasks were kept at a temperature of about 50° F. Similar results were obtained with ale, meat-juice, vegetable infusions, etc.

It is probable that the micro-organisms were frozen solid. One cannot suppose that in these circumstances any of the phenomena of life take place: the mechanism is simply arrested, and vital changes resume their course, when the condition of a suitable temperature is restored. These considerations led the authors to examine whether any of the vital phenomena of higher animals might be retained at such low temperatures. They ascertained that a live frog may be frozen through quite solid in about half an hour at a temperature of — 20° F. to — 30°. On thawing slowly, in two instances the animal completely recovered. After longer exposure the animals did not recover. In two cases frogs were kept in an atmosphere of — 100° F. for twenty minutes, and although they did not revive, yet, after thawing out, their muscles still responded feebly to electrical stimulation. One experiment was performed on a warm-blooded animal, — a rabbit. The cold-blooded frog became as hard as a stone in from ten to twenty minutes, but the rabbit produced in itself so much heat as enabled it to remain soft and comparatively warm during an hour's exposure to — 100° F. Still its production of heat was unequal to make good the loss; and every instant it was losing ground, until, at the end of the hour, its bodily temperature had fallen about 56° F. below the normal, but was still 143° F. above the surrounding temperature. When taken out, the animal was comatose, and reflex action was abolished. Placed in a warm room, its temperature rose rapidly, and the rabbit completely recovered.

The observations are of great value, and highly suggestive. Those upon the rabbit indicate that death from cold is preceded by loss of consciousness, owing to the early suppression of the activity of the gray matter of the encephalon. This confirms the belief that death by freezing is comparatively painless. The viability of microbes at low temperatures has also been demonstrated by Pictet and Yung,[1] who found that various bacilli can survive — 70° C. for a hundred and nine hours. After such exposure, Bacillus anthracis retained its virulence when injected into a living animal.

We cannot refrain from asking, Are not frozen micro-organisms the means of disseminating life through the universe? An affirmative answer is at least a better hypothesis than the assumption of spontaneous generation to account for the origin of life on the earth. May not life be coeval with energy? May it not have always existed?

CHARLES S. MINOT.

[1] *Comptes rendus*, Paris, xcviii. 747.

PREHISTORIC AMERICAN SCULPTURES.

AMONG the many interesting sculptures in stone of the prehistoric Americans are those found in

HUMAN SACRIFICE. BAS-RELIEF AT SANTA LUCIA COSUMALHUPA. (*La Nature.*)

Guatemala, which were first described by Dr. Habel in No. 269 of Smithsonian contributions to knowledge, 1879. These were principally fallen monoliths which were discovered in 1862, near the village of Santa Lucia Cosumalhupa, near the base of the Volcano del Fuego. Several of these carvings were afterwards secured by Dr. Bastian for the Berlin museum. The majority of those figured by Dr. Ha-