years; when deemed wise by the Board of Directors, special grants of limited sums may be made to support the work carried on under a fellowship.

THE Committee on Scientific Research of the American Medical Association invites applications for grants of money to aid in research in problems bearing more or less directly on clinical medicine. Preference is given to requests for modest amounts to meet specific needs. As a rule grants are not made for the purchase of equipment or apparatus of a permanent nature. For application forms and further information, address the committee at 535 North Dearborn Street, Chicago.

DISCUSSION

AURORAL DISPLAY AND GEOMAGNETIC STORM OF SEPTEMBER 18–19, 1941

ONE of the greatest auroral displays ever observed in the central Atlantic and mid-central portions of the United States occurred on the night of September 18–19. Spectacular displays continued from twilight until just before dawn, and were observed as far south as Florida and southern California. The auroral activity accompanied one of the most violent magnetic storms of the present sunspot-cycle, nearly equaling in intensity and exceeding in duration the great storm of Easter Sunday, March 24, 1940. Serious interference with radio and wire communications over long distances was experienced, as well as noticeable effects on electric power-transmission lines.

This geomagnetic storm is generally ascribed to clouds of electrified particles projected from the sun in the region of an extraordinarily active sunspot-group which had crossed the solar meridian shortly before the onset of the disturbance. The progress of this sunspot-group across the sun had been followed by a number of observers for several days. Just at the time of crossing the solar meridian an increase in activity in the group was noted. Since such active groups frequently give rise to geomagnetic disturbances, H. W. Wells, of the Department of Terrestrial Magnetism, Carnegie Institution of Washington, had warned numerous radio operators to be on the lookout for disturbances in radio transmission-conditions, so that occurrence of the magnetic storm was not entirely unexpected by scientists, although its great intensity and the extent of the auroral manifestations were not anticipated.

The storm began at 11 P.M., Eastern Standard Time, on September 17 and attained maxima of activity between 1 and 3 P.M., and between 7 and 10 P.M. on September 18. During both of these periods of intense activity, effects were noted on the 230-kilovolt interconnecting line tying the power-system of Washington, D. C., into the hydroelectric developments along the Susquehanna River in Pennsylvania, approximately 100 miles to the north. The second period of disturbance also was the time of maximum auroral activity. Changes in horizontal magnetic intensity at the U. S. Coast and Geodetic Survey Observatory at Cheltenham, Maryland, amounted to over 2,500 gammas, which is approximately 15 per cent. of the normal value at that station, the greatest change ever recorded there.

During the second active interval, which occurred during the hours of darkness, bundles of auroral rays were directed downward through the high atmosphere over the eastern section of the United States. These rays, because of the electrical nature of the particles causing them, took the direction of the earth's magnetic field and consequently assumed roughly parallel directions and approached the earth's surface in alignment with the magnetic dip which at Washington, D. C., is nearly 20° from the vertical. To observers viewing these rays they appeared to be parallel, and like all parallel lines, appeared to converge in the distance. For this reason many persons noted a spectacular coronal display of the aurora borealis where the rays appeared to converge slightly south of the true zenith toward a point known as the magnetic zenith.

Throughout the night the auroral activity exhibited various forms. At times extensive quiescent auroral arcs crossed the sky in a roughly east-west direction. These changed into draperies, rays and curtains, as the various auroral forms are picturesquely described. In the extreme northern part of the country and in southern Canada brilliant colors in the aurora were reported by many observers, although throughout the greater portion of the United States the auroral forms were with little color although occasional casts of red and green could be detected. Auroral displays were observed in the northern part of the United States on the nights of September 17–18 and 19–20 also, but of greatly diminished intensity.

No complete theory of geomagnetic storms and aurora has been developed. The most generally accepted theory attributes both to the injection into the earth's atmosphere of high-velocity electrified particles projected from active regions on the sun. These particles, entering the tenuous layers of the upper atmosphere, excite the molecules and atoms of the air and thus give rise to the auroral light in very much

the same manner as glows are produced in neon signs. The energies of these particles also ionize the atmospheric gases and render them electrically conducting so that large electric currents flow through the upper atmosphere. These produce the magnetic effects recorded by magnetic instruments and also induce electric currents in power and telegraphic lines. This electrification of the upper atmosphere is irregular in formation and consequently destroys the reflecting properties of the smooth but lesser conducting layers normally present which are responsible for reflection back to earth of radio waves traversing long distances. During the magnetic storm of September 18–19 electric currents flowing in the earth's atmosphere probably attained values of several million amperes.

Magnetic storms of intensity comparable with the recent one are extremely rare, occurring as a rule only once or twice during each sunspot-cycle. Since the present sunspot-cycle is now well on the decline, it is extremely unlikely that so great a magnetic storm accompanied by a spectacular auroral display will occur again for a considerable number of years.

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MOSSES IN THE VIRGINIA CAVERNS[1]

RECENTLY when on a visit to Luray Caverns in the Shenandoah Valley of Virginia I was surprised to see a pronounced green color appearing on many of the drip-stone formations that I had not noticed many years previously. It was evident that this green coloration was related in some way to the illuminating system, for it showed at its best on the rocks brilliantly lighted by the reflecting projectors. On close examination it was found to be a chlorophyl plant. A specimen submitted to the Farlow Herbarium of Harvard University was determined as an atypical sterile moss of the Order Hypnobryales.[2] More recently a collection of these mosses has been submitted to the Harvard herbarium for more specific identification.

Before the electric illuminating systems were installed in the Virginia caves no sign of moss or other green plant life had been seen in their dark interiors. The lighting systems were installed in most of the caves about 1922 or shortly thereafter. The moss is variously reported to have appeared in two months to two years time after the lights were put in service. With the introduction of larger bulbs and more efficient reflectors, the moss has spread over wider areas to the extent that the green tone is almost as much a part of the coloration of the cavern as the natural browns, buffs and white of the drip-stone formations. This greenish color is not objectionable but rather adds a pleasing variation to the natural color scheme.

Apparently the spores of mosses living on the surface of the ground above the caves are carried by the ground-water seepage into the caves. If they are fortunate enough to lodge within an intensely illuminated area the spores germinate and develop into mosses as much as two to three inches in length. Even ferns have been reported to grow in the caves.

Whether these mosses require the light and heat from the visible range of the spectrum or whether they can develop in total darkness under the influence of infra-red radiation is not known. But certain it is that they have not been able to germinate in these caves without the support of radiation from the electric lamps. The amount of light, or rather the extent of the time of illumination, may range from an hour or two to fourteen hours a day, depending upon the season of the year. In summer, the busy tourist season, the plants in the caves may be bathed with artificial light for as many hours a day as if they were living outside. In winter when the periods of illumination are short the plants may turn yellowish or brown and die.

As mosses are land plants their introduction into caves by the vadose waters is a relatively simple process. The wind is not a likely means of transportation of the spores, more particularly in the Luray Caverns where no noticeable air circulation is reported. The spores of mosses are apparently present at all moist places and are awaiting only sufficient light to germinate, and they in turn provide a means of support for animal life which exists with them. Algae on the other hand are water plants and their continuous introduction into areas above the water table is not so likely. Where surface streams become cavern streams there is apparently no reason why algae may not grow in caverns under the influence of sufficient artificial illumination.

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U. S. GEOLOGICAL SURVEY

STONE MAN CAVE, SHASTA COUNTY, CALIFORNIA

INVESTIGATION of cave deposits in northern California was initiated in 1903 by Dr. John C. Merriam, and excavations were carried on up to and during 1905, principally in the Potter Creek and Samwel Caves. One cave, the Stone Man Cave, approximately 30 miles north of Redding, was examined by Dr. Merriam and the writer, but some doubt existed as to its antiquity, owing to the paucity of animal remains in the cave.[1]

[1] Published by permission of the Director, U. S. Geological Survey.

[2] Through the kindness of Dr. Franz Verdoorn, the specimen was subsequently forwarded to Professor W. C. Steere, of the University of Michigan. He pronounced it to be *Leptobryum pyriforme*.

[1] *Am. Anthropologist* (NS) 8: 2, April–June, 1906.