throughout the Lake States, for example, few plantations can survive satisfactorily without fencing or other protection. Horn tells us that direct seeding in the California pine region is hopeless unless the mouse population is held to less than one mouse per 50-trap nights.

These few citations serve to emphasize not only the importance but the widespread extent of the biological factor in silvicultural operations. No doubt other phases of it will come to our attention as time and resources permit the expansion of biological investigations to additional regions and problems.

The study of the animals themselves, their life habits and so on, are of course primarily the task of the forest biologist. Some of the questions which the silviculturist must put to the biologist are:

(1) What are the important forest-inhabiting animals and birds affecting forests and forest practices?

(2) What is their life cycle, their food habits, etc.?

(3) What effect will the destruction of other animals, including predators, have on them?

(4) How are they affected by environmental changes which the silviculturist may make—as through clear cutting, etc.?

The forester must have the answer to these and similar pertinent questions before satisfactory forest-cutting practices can be worked out in silvicultural terms.

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THE FORMALDEHYDE–PROTEIN REACTION

CLARK and Shenk[1] in a study of the action of formaldehyde upon proteins found evidence which they interpreted upon the basis of compound formation. This evidence, observed by x-ray diffraction methods, consisted essentially of two new interplanar spacings corresponding to values of 2.6 and 3.9 A.U.

The presence of these new diffraction rings in the case of fibrous proteins characterized by ready swelling in alkali (feather, hair, tendon) and their absence in proteins relatively inert to alkali (silk) was construed to be indicative of reaction at the amide nitrogen. The mutually perpendicular fibering of these new interferences in the case of fibrous proteins was considered as being in accord with this interpretation.

Subsequent work at this laboratory undertaken at the suggestion of Professor J. H. Highberger and in conjunction and agreement with experimental work on proteins at the United States Regional Soy Bean Industrial Products Laboratory at this university indicated, however, that the new interferences could be accounted for upon the basis of the polymerization of formaldehyde retained in the protein.

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BACTERIA IN DUST-LADEN SNOW

ON March 5, 1938, a snowfall occurred in the Ottawa district which brought down with it a considerable amount of solid matter sufficient to produce a distinct brownish discoloration. According to the Meteorological Division, Department of Transport, such winter dust falls are reported from time to time from certain stations in Northern Ontario and Quebec. The dust is believed to have originated in the Western States, a low pressure area centered over Arizona and Texas on March 3 to 4 having reached Michigan and Ontario on March 5. Carried at high levels the dust current encountered cold air moving west when condensation to snow brought the dust particles down.

Bacteriological analysis of samples, collected in open country previously covered by fresh clean snow, gave a count of 4,370,000 organisms per gram of deposit. Examination of plate colonies showed them to consist almost entirely of spore-forming types, only one non-spore-former, a micrococcus, occurring on the highest dilution plate of twenty-five colonies. *Bacillus megatherium* was the most abundant species. Others noted were *B. vulgatus, B. mesentericus, B. mycoides, B. simplex, B. cereus* and *Bacillus sp.* The predominant organisms encountered were thus types commonly found in soil and which might be expected to withstand well such adverse conditions as desiccation and low temperature.

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SOCIETIES AND MEETINGS

THE NOTRE DAME SYMPOSIUM ON THE PHYSICS OF THE UNIVERSE AND THE NATURE OF PRIMORDIAL PARTICLES

A SYMPOSIUM dealing with the structure of the universe, cosmic rays and the ultimate constituents of matter and attended by more than 100 visiting scientists from 30 other colleges and universities was held at the University of Notre Dame on May 2 and 3, 1938. The symposium, arranged by Dr. Arthur Haas, comprised three public lectures and several technical sessions at which Dr. Arthur H. Compton, of the University of Chicago, Dr. Harlow Shapley, of Harvard University, Dr. Carl D. Anderson, of the Califor-

[1] *Radiology*, 28: 357, 1937.

nia Institute of Technology and Dr. Gregory Breit, of the University of Wisconsin, presided.

Professor Shapley's lecture dealt with the distribution of matter in the metagalaxy. Of the six possible categories of material in metagalactic space, we have, according to Dr. Shapley, positive knowledge of the existence of only two, namely, galaxies and radiation. We have preliminary evidence of a third category—star clusters. Of isolated stars and of meteorites and gas, we have no evidence and can make only rather insecure inferences. Calculations based on the "short time-scale" show that the density of intergalactic radiation is approximately 10^{-35} grams per cubic centimeter. A few of the remotest globular clusters, studied at Mount Wilson and Harvard observatories, appear to lie beyond the bounds of our galactic system, but they are still within the local group of galaxies. The principal known constituents of the metagalaxy are the spiral, spheroidal and irregular galaxies. The rough uniformity of their distribution throughout space has permitted preliminary simple deductions concerning metagalactic structure. New investigations of groups, clusters and clouds of galaxies, and especially of important population-gradients within a hundred million light years of the observer, impel us, however, to revise the concepts based on the hypothesis of uniformity. In particular, a well-surveyed region 110 degrees long in the southern galactic hemisphere shows a remarkable density-gradient—near the south pole the density is more than five times that near the equator. A study of the 90,000 faint galaxies in the south galactic polar cap reveals large inequalities in population density. On the basis of this extensive new material it is found that tests of the expanding universe hypothesis are still indeterminate. The study of the nearest and most significant of the supergalaxies, the cluster in Virgo, has shown the reality of the long extension of the system into the southern hemisphere. The cluster is more than five million light years in extent and is composed almost exclusively of galaxies brighter than the 15th magnitude. A survey of galaxies around the north pole of the skies serves to outline the clouds of absorbing material that lie in our own galaxy in that direction. These various results are all a part of a survey from Harvard's northern and southern stations of the distances and brightnesses of the observable galaxies, estimated at about 600,000, that lie within a hundred million light years of the milky way.

Canon Georges Lemaître, of the University of Louvain, at the present time visiting professor at the University of Notre Dame, discussed the significance of the clusters of nebulae. He compared new data about these clusters with the theory propounded by him, according to which the clusters are equilibrium regions of the expanding universe where the cosmical repulsion and the gravitational attraction balance one another. This hypothesis enables one to compute a theoretical mass of a nebula from the observed red-shift. The mass found in this way is 700 million suns in excellent agreement with the value found by Hubble from spectroscopic rotation. On the contrary, Sinclair Smith, who rejects Lemaître's hypothesis and interprets the large peculiar velocities of nebulae in clusters as an indication of a predominant effect of gravitation, finds a mass which is a hundred times bigger than Hubble's value. The big velocities of the nebulae of a cluster are easily explained by the theory of the expanding universe. The typical clusters of nebulae are extreme cases of the large fluctuations of density which have been found by Shapley and Hubble. When we take account of the uncertainties due to the large dispersion of the velocities in the clusters, it is clear that the discrepancy from a perfect linearity of the velocity-distance relation is within the observational errors and that the cosmological consequences deduced from them by Hubble (which practically imply the rejection of the relativistic theory of the expanding universe) are not really justified by actual observations.

In his paper on the heat of the stars and the building of atoms in the universe Dr. William D. Harkins, of the University of Chicago, arrived at the conclusion that the composition of the stars is about what it should be if they began their existence billions of years ago as bodies composed of hydrogen alone, provided there has been some process which has been able to produce the great amount of neutronic matter essential for the building of heavier atoms.

The topic of Dr. Arthur H. Compton's lecture was the question "Whence Cosmic Rays?" With the discovery of the effect of the earth's magnetic field, it became evident, as Dr. Compton showed, that the cosmic rays were not like gamma rays but consist mainly of electrical particles. These in general do not go in straight lines. Thus it becomes impossible from the observed isotropic character of the rays as they reach the earth to infer that their origin is likewise isotropic. In fact, following a suggestion very recently made by Alfven, it may be shown that if the cosmic-ray particles are predominately of one sign, there must be slowly moving ions following the motion of the stars which, together with the cosmic ray particles, would produce large magnetic fields if the cosmic ray particles themselves do not follow the stars. These fields might in fact be comparable with the magnetic field of the earth and should in any case cause curvature of the paths of the cosmic ray particles that would be short compared with interstellar distances. Alfven thus concludes that the observed isotropic character of the cosmic rays tells nothing about their point of origin but is a consequence merely of the fact that

the rays consist of electrically charged particles. This result means, according to Dr. Compton, that the cosmic rays can not readily escape from the galaxy nor could rays from outside the galaxy readily come into it. Any sidereal time variation such as that ascribed to a motion of the earth relative to cosmic rays coming from outside the galaxy should thus be impossible unless there are some rays of a non-galactical type. On the other hand, no great source of cosmic ray power would be required since the energy, once developed, would stay within the galaxy. Thus, although the cosmic ray power reaching the earth is roughly equal to that of starlight, the rate of production of cosmic ray energy by the galactic system would be far less than that of starlight. It would seem possible, in fact, that in the interaction of cosmic ray particles on stars in motion relative to each other there might be found a source of the new energies of the cosmic rays. This source would consist of the gradually increasing energy of the particles as they bounce back and forth among the moving stars.

Interesting aspects of the cosmic ray problem were discussed by Dr. Anderson. He dealt especially with the difficulties which inhere in the attempts to explain the observed cosmic-ray phenomena in terms of the assumption that the cosmic-ray particles are practically all protons and positive and negative electrons. According to Dr. Anderson, these difficulties may be resolved by postulating the existence of new particles of unit positive and negative charge and with a mass whose magnitude lies between that of a proton and that of an electron. Data pertaining to this question come from two types of observations, firstly determinations of the penetrating power and of the production of secondaries by cosmic-ray particles of various energies, and secondly, by observation of heavily ionizing particles under conditions where information concerning their curvature in a magnetic field and their range may be obtained.

Dr. Manuel S. Vallarta, of the Massachusetts Institute of Technology, discussed the influence of the magnetic field of the earth on cosmic-ray particles and summarized the results of his investigations in the following way: At a given point of the earth particles of a given energy may arrive only from certain regions of the sky; there is a cone of complicated shape within which all directions are allowed, another cone outside which all are forbidden; in the intermediate regions certain directions are allowed and the rest forbidden. The boundaries of these several regions are determined from a study of the trajectories of the primary rays. Since the equations of motion can not be integrated in terms of known functions, the trajectories were found by means of Bush's differential analyzer, which has played a very important role in these investigations. Conclusions can be drawn that most of the primary cosmic rays are electrically charged particles and that they are predominantly—at least three quarters—positively charged.

Dr. J. F. Carlson, of Purdue University, gave a detailed theory of cosmic ray particles. According to Dr. Carlson, the shape of the ionization curves in the upper atmosphere and of the Rossi transition curves in various absorbers can be explained by assuming that the incoming rays consist in part of highly energetic electrons and positrons, whose behavior can be predicted from the quantum theory of radiation. According to theory, charged particles will radiate and gamma-rays will produce electron-positron pairs in nuclear fields. This multiplicative process will continue until the original energy of the gamma-ray is distributed over a large number of less energetic particles; these will lose energy largely by collision and ionization. Specific predictions of the theory are in satisfactory agreement with experiment, and direct evidence for the nature of the process has been given. Effects observed for large thicknesses of absorbing material may be explained by the existence of a penetrating component which is not electronic in character.

The nature of forces between primordial particles was discussed by Dr. Breit. The force between two protons is known to a certain extent through the experiments on the scattering of protons in hydrogen. The interpretation of these experiments by Breit, Condon and Present, and with improved accuracy by Breit and Stehn, shows that this force is nearly the same as the force between a proton and neutron as determined by Fermi and Amaldi by scattering neutrons in hydrogen. Comparison of mass defects of isobaric nuclei indicates also approximate equality of these forces to the neutron-neutron-force. Although the forces are approximately equal, there appears to be a definite indication that the proton-proton force is smaller than the neutron-neutron force and almost as definite evidence that it is smaller than the proton-neutron force. Theoretical considerations indicate that the forces are of an exchange character.

Dr. Eugene Guth, of the University of Notre Dame, presented a paper in which he treated the possible wave-equations for the primordial particles. He discussed especially the possible disintegration of nuclei by fast electrons. Experiments for detecting such an effect with beryllium are running with the electrostatic generator of the University of Notre Dame, which was recently constructed by Dr. Collins and gives a current of 30 microamps at two million electron volts (corresponding to the electron emission produced by 6 kg radium).

In his paper on "Cosmic Constants" Dr. Arthur Haas, of the University of Notre Dame, derived a new relation connecting constants of atomic physics on the basis of the theory of the universe. This relation states

that the radius of the electron is related to the Compton wave-length of the proton as 3 to $\sqrt{2}$. This may be interpreted as indicating that in the state of equilibrium of the universe one third of its primordial particles are protons, one third electrons and one third neutrons.

THE DEPARTMENT OF PHYSICS
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SPECIAL ARTICLES

IMMUNIZATION AGAINST EQUINE ENCEPHALOMYELITIS WITH CHICK EMBRYO VACCINES[1]

EQUINE encephalomyelitis is a virus disease which, during the past few years, has become increasingly prevalent in many parts of the United States. Fortunately, vaccines capable of producing immunity in susceptible animals can be prepared by formalinizing brain tissue from animals dying of the disease.[2,3] The horse brain now used for large-scale vaccination constitutes a relatively poor and inconstant source of virus. There is much evidence that the immunizing capacity of a vaccine of this sort is proportional to the amount of virus in the tissues before treatment with formalin. We have accordingly sought to produce a better vaccine by utilizing the exceptionally infectious tissues of chick embryos[4] diseased with the virus.

The high virus content of embryos has been emphasized by the fact that it has proved possible to isolate[5] from them, but from no other tissues, a homogeneous substance which seems to be the infectious agent. We have already prepared formalinized extracts of such tissues and have demonstrated that the immunizing principle they contain can be concentrated by ultracentrifugation.[6] In further experiments we have now studied the immunizing capacity of the formalinized embryonic tissues themselves and have compared it with that of the usual vaccines made from horse brain.

The viruses of both the Eastern and Western strains of equine encephalomyelitis grow equally well in chick embryos. The tissues of embryos diseased with the Eastern strain virus regularly attain a titre of 3×10^9 and under proper conditions 3×10^{10} mouse infective units per gram. The titre of the Western strain chick virus routinely lies between 3×10^8 and 3×10^9 m.i.u. per gram. The virus concentration in these tissues is 1,000 to 10,000 times greater than in the most infectious horse brain we have examined and the chick vaccine has proved to be correspondingly more effective as an immunizing agent.

Chick vaccine against the Eastern strain of equine encephalomyelitis has been tested by injecting guinea pigs with two doses at an interval of seven days. Two weeks after the second injection they have received an intracerebral[7] inoculation of 500 minimal lethal doses of virus-diseased horse brain. Of thirty animals vaccinated with eight different batches of vaccine every one was solidly immune and survived the test inoculation of virus with no evidence of disease. All control animals succumbed promptly.

Western strain chick vaccine is equally effective in protecting guinea pigs. One group of experiments utilizing 60 animals has demonstrated its superior immunizing capacity compared with that of a corresponding horse brain vaccine. The chick vaccine protected every tested guinea pig against 1,000 m.l.d. of virus, whereas no animal receiving the horse brain vaccine survived a test injection of 100 m.l.d. In preliminary experiments it has also protected every vaccinated horse against the intracerebral injection of enough virus to kill all the control animals.

In these experiments the vaccine consisted of a 10 per cent. diseased tissue suspension containing 0.4 per cent. formalin. A 1 per cent. chick vaccine has protected about 60 per cent. of the vaccinated animals; more dilute vaccines have proved worthless.

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PROTOPLASMIC STREAMING, ELECTRIC POTENTIALS AND GROWTH IN COLEOPTILES OF TRITICUM AND AVENA

THE effect of electric potentials on protoplasmic streaming in coleoptiles of Triticum and Avena in relation to transport and growth has been studied. Cholodny *et al.*[1] have reported that applied currents mainly decrease growth; Lund *et al.*[2] relate polarity of the plant with observed electric polarity, while on the other hand Clark *et al.*[3] report that the electric

[1] The part of this work carried out at Duke University has been made possible through the interest and aid of Lederle Laboratories, Pearl River, N. Y.

[2] M. S. Shahan and L. T. Giltner, *Jour. Am. Vet. Med. Asn.*, 84: 928, 1934.

[3] P. K. Olitsky and H. R. Cox, *Jour. Exp. Med.*, 63: 745, 1936.

[4] E. Higbee and B. Howitt, *Jour. Bact.*, 29: 399, 1935.

[5] R. W. G. Wyckoff, *Proc. Soc. Exp. Biol. and Med.*, 36: 771, 1937.

[6] J. W. Beard, H. Finkelstein, W. C. Sealy and R. W. G. Wyckoff, SCIENCE, 87: 89, 1938.

[7] Operations on animals were made under full ether anesthesia.

[1] N. Cholodny and E. Sankewitsch, *Plant Physiol.*, 12: 385, 1937.

[2] E. J. Lund, *Jour. Exp. Zool.*, 51: 265, 1928.

[3] W. G. Clark, *Plant Physiol.*, 12: 409, 1937; *ibid.*, 12: 737, 1937.