natural condition of the structure is maintained, there being but little shrinkage. Cell contents relatively insoluble in water, but soluble in xylol and oils, are not lost. Sections as thin as 10 microns can be cut with ease. However, serial sections can not be cut, nor can some stains be used unless the gelatine is dissolved away after sectioning, which is not easy to do. The method is as follows: Ordinary cooking gelatine is soaked two or three hours, or until it will absorb no more water, then after the excess of water is poured off it is warmed until melted. A temperature of not over 70 degrees Centigrade should be maintained. Part of the liquid gelatine is now thinned with an equal volume of water and the material to be embedded is kept in this dilute gelatine for several hours, during which it must be warm enough to remain liquid. Following this, concentrated gelatine is used similarly for several hours more. The dishes containing the material being embedded should be corked to prevent drying. The material is now cooled in a paper tray coated with paraffin, after which it is hardened for several days in 4 per cent. formalin. The microtome knife must be sharp, with no bevel on the lower side, and set at as great an angle as possible. Either alcohol or water may be used to flood the knife in cutting. Pieces of the gelatine with embedded material are, as a rule, strong enough to be clamped in place in the machine without wooden blocks as supports.

Materials which can not be cut otherwise yield easily to the knife after the use of dilute or concentrated hydrofluoric acid[4] for one to three weeks, which is followed by thorough washing in water, then the regular paraffin method. Ample time for each stage of the paraffin method to permit dehydration and embedding of the large pieces must be given.

Acknowledgment for many suggestions is made to Dr. L. L. Burlingame, of the botany department of Stanford University.

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[4] Bailey, I. W., "Microtechnique for Woody Structures," *Bot. Gaz.*, Vol. 49, January, 1910, p. 58.

THE ECOLOGICAL SOCIETY OF AMERICA

A MEETING of the Ecological Society of America was held in the High School building at San Diego, California, on August 10 and 11, 1916, and two joint sessions were held with the Western Society of Naturalists. About twenty-five members were present, the chair being occupied by the secretary-treasurer. Members of the society participated in the biological dinner at the U. S. Grant Hotel on the evening of August 12. On the afternoon of that day the work of the Scripps Institution was demonstrated by members of its staff. On August 13 and 14 the members of the Ecological Society were guests of the San Diego Society of Natural History on a 200-mile automobile trip to the Cuyamaca Mountains and the edge of the Colorado Desert.

Following are abstracts of papers presented at the sessions of the society:

The First Stage in the Recession of the Salton Sea: D. T. MACDOUGAL.

The Trees and Shrubs of the Grand Canyon of the Colorado: ALICE EASTWOOD.

The zones of plant life in the Grand Canyon may be defined by the trees and shrubs which characterize them. The great diversity of environment results in complexities of distribution which offer a promising field for ecological investigation. Fifty lantern slides were shown, made from herbarium specimens of the leading trees and shrubs of the Canyon, collected on the Bright Angel, Hermit and Berry trails.

Results of the Effect of Chaparral and Forest Cover on Meteorological Conditions: EDWARD N. MUNNS.

Records have been taken daily at three stations at the Converse Experiment Station, for three successive years. One station is located in an open cienega, one in a chaparral field, the third in a forest of jeffrey pine, all stations being about 6,000 feet elevation.

The records show the mean annual temperature under the chaparral cover is 2°.8 higher than in the open, and that of the forest 1°.2 higher. More important are the extremes, the mean maximum in the chaparral, being 5°.7 higher and the mean minimum 2°.0 lower than in the open, while the mean maximum under forest conditions is 1°.4 lower and the mean minimum 3°.8 higher than in the open. The mean daily range in the open is 26°.5, that of the chaparral 7°.7 greater, and that in the forest 5°.2 less.

Soil temperatures are greatest in the open, and least in chaparral with a difference of 1°.0 be-

tween chaparral and forest, and 6°.0 between chaparral and open, the differences being greater in summer and least in winter.

Eighty per cent. of the precipitation reaches the ground under chaparral and seventy-two per cent. under the forest, much more water reaching the ground from snowfall under chaparral than forest. A difference of 5 per cent. exists between open and areas under cover, though there is but slight difference between the types of cover. Evaporation in the forest is 85.2 per cent. that of the open, while the chaparral evaporation is but 47.2 per cent.

Plant Succession in Badlands: Frederic E. Clements.

An account of the revegetation of the highly eroded clays and shales, known as Badlands. The areas considered are the Oligocene-Miocene deposits of the Hat Creek Basin in Nebraska, and of the White River in South Dakota, the Eocene of the Little Missouri in North Dakota and Montana, Miocene volcanic deposits in Wyoming, and the Mancos Shales of Colorado, Wyoming, Utah and New Mexico. In the last, the climax is the *Atriplex-Artemisia* formation of the Great Basin region. In all the others, the climax is the prairie-plains grassland, except in the Black Hills proper, where it is the *Pinus ponderosa* forest. The soil water of the Mancos Shales is saline, and the succession type is the halosere, consisting of halophytes and terminating in a sage-brush climax, or rarely in juniper-piñon woodland. In all the Tertiary Badlands of the Great Plains region, the fine-grained compact soil, the steep slope and the low but torrential rainfall make xerophytic succession, as represented by the xerosere, typical. The hydrosere and halosere are relatively rare, while subseres are especially favored by the nature of the soil. The climax is usually reached in the *Stipa-Agropyrum* prairie association. In drier regions, the climax is the *Bulbilis-Bouteloua* short-grass association, and in wetter ones, the *Pinus ponderosa* consociation.

A Summary of Bog Theories: George B. Rigg.

A discussion of the character and occurrence of sphagnum bogs, and a presentation of the theories that have been advanced to account for the xerophily of bog plants, the possible sources of toxic substances in bog water, and the manner in which these substances influence the activities of plants.

Vital Statistics of the Yellow Pine through an Altitudinal Gradient of Climatic Conditions: Forrest Shreve.

Vital statistics have been secured for *Pinus arizonica* at elevations of 6,000, 7,000, 8,000 and 9,000 feet on south-facing slopes in the Santa Catalina Mountains, Arizona, and on north-facing slopes at 6,000 and 7,000 feet. The number of adult trees (10 cm. and over) per unit area decreases with decrease of altitude, except on the south-facing slopes at 6,000 feet. The total volume per unit area decreases with decrease of altitude, the exceptional stand at 6,000 feet being composed of a relatively large number of small trees. The number of seedlings and smaller trees bears no relation to altitude on the areas examined. Curves were exhibited showing the rate of growth at the four altitudes.

The Influence of Environmental Conditions in the Origin of a Narrowly Localized Race of Mice: Francis B. Sumner.

The Distribution of Pocket Gophers in California: Joseph Grinnell.

On Some Varieties of Thais (Purpura) lapillus and their Relation to the Environment: Harold S. Colton.

On account of its abundance and great variation, *Thais (Purpura) lapillus* forms a very favorable material for a study of some of the conditions of life on the rocky shores of the New England coast. Over twelve thousand shells were collected and sorted from sixty-seven localities in the neighborhood of Mount Desert Island, Maine. *Thais* is found in the rock association and the boulder association of the littoral formation wherever its food, *Balanus*, the barnacle, and *Mytillus*, the mussel, is found. The environments were classified according to the size of the waves on the beach and on the color and character of the rocky substratum. A study of the varieties showed that (1) in the surf and in the sheltered harbor the snails of a given age were smaller and darker than those found in the bays. More were also apt to be lamellated in the surf or harbor than in the bays; (2) light forms are apt to be found on light-colored rocks, but there is no great correlation between yellow snails and yellow rocks or banded snails on banded rocks; (3) there are other factors which act on a whole region irrespective of the wave action or substratum. An example of this was found in comparing the number of lamellated forms in the Somes Sound region with the Blue Hill Bay region adjoining. In the former, whether in harbor, bay, or surf, lamellated forms are rare (6 per cent.). In the latter they are common in the harbors, as much as 96 per cent. in some, absent in the bay but common (17 per cent.) in the surf.

Thais feeds in this region on barnacles and mussels. It is destroyed (1) by cannabalism within the egg capsule; (2) by fish when young; (3) by herring gulls when old; (4) by shore ice in the winter. A comparison of collections made on islands on which the gulls breed, with situations where there are not so many, seems to show that the proportions of color found are determined by selection.

An Inquiry into the Relative Importance of the Various Phases of the Environment in Determining Plant Distribution: WM. E. LAWRENCE.

This paper presents the results of an inquiry into the literature to ascertain what researches throw light on the problems of plant distribution. It includes a discussion of the relative importance of phylogeny, historic geology, climatic cycles, topography, climatic and edaphic factors as they affect the distribution of plants. The inherited physiological and morphological characteristics of a plant, on account of its phylogenetic relation, are considered first because they define the limit of the plant's response in terms of the environment. Geological factors have, of course, greatly influenced the preceding, but they are equally important in determining the components of the endemic flora. Climatic and edaphic factors are effective at present. Of these no one factor or combination of factors is found to be all dominant. Under certain less variable conditions or combination of factors, the more variable factor or factors appear to dominate the physiological activity of the plant and hence determine its success in such an environment. There are, therefore, no limiting factors in plant distribution except as the conditions are defined. Under proper conditions every known factor in nature may limit growth and reproduction, hence distribution. The control of these conditions one by one is exactly the method of experimentation. When we attempt to analyze the natural conditions, we merely interpret according to the laws of experimentation. There seems to be good reason to believe that the distribution of certain plants and plant associations are in some cases limited by one factor such as water and in other cases by other factors such as temperature. The whole situation is likely to be obscured in nature because of the innumerable possibility of combination and the factors of preoccupation and competition. An ecological classification is presented based upon the greatest variable factor for any given area, whether the area is defined on the basis of physiography, plant association, or other limits.

On the Relation between the Rate of Root Growth and Oxygen: W. A. CANNON.

A series of experiments is reported on in which the roots of *Prosopis velutina* and of *Opuntia versicolor* are exposed to atmospheres of (1) pure carbon dioxide, (2) and atmospheric air so diluted with carbon dioxide that a mixture containing 5 to 25 per cent. oxygen results. It was found that the roots of both *Prosopis* and *Opuntia* can maintain a feeble growth rate in an atmosphere containing as little as 5 per cent. oxygen, but that root growth in both species stops in pure CO_2. The recovery from the asphyxiation occurs sooner in *Prosopis* than in *Opuntia,* and in both at higher sooner than at lower soil temperatures. The results indicate that the response of the roots of *Opuntia* to a diminished oxygen supply, such as occurs with increasing depth beneath the surface of the ground, is a contributory factor among those which bring about the superficial placing of its roots.

The Relation between Marine Biology and Ecology: ELLIS L. MICHAEL.

To understand marine organisms is the function of marine biology. To what extent, how, and why are marine organisms adapted to the particular environments in which they live? In short, by virtue of what is a marine organism marine? This is the central question in marine biology: all others are strictly tributary to it. Fully grasped, this means that the significance of no phenomenon essential to the life of any marine organism can be fully understood so long as any other phenomenon likewise essential to it is entirely ignored. Knowledge of the environment is therefore as indispensable to a complete understanding of marine organisms as is that of the organisms themselves. Continuous and intimately coordinated investigations in chemistry, physics and hydrography as well as in morphology, embryology and physiology are indispensable. There is, therefore, a certain natural order of progress in marine biology. Details can not be stipulated, but this much is certain: after the various organisms to be investigated have been identified, it is necessary to determine how they are related to the elements of their environmental complexes before it will be possible to discover how or why these relations are maintained. That is, the initial step must be one in field ecology. Then would follow the more intensive studies of structure, function and behavior—morphology, embryology, physiology and experimental ecology—required to fully

understand the organism as it actually lives in nature. Not until this has been accomplished may it be truly claimed that an investigation in marine biology has been carried to its logical termination. This same conception, of course, applies to land organisms and fresh-water organisms; to mountain biology, desert biology, lake biology, river biology, etc. It is that conception which insists that no organism can be fully understood, in its structure and function quite as much as in its distribution and behavior, apart from its natural abode.

Variations of Picris echioides: R. R. GATES.

Picris echioides is a European plant introduced into California. In a small colony of this composite at Berkeley several marked variations were observed. The most interesting of these were two individuals in which all the florets of the heads were "quilled" or tubular, instead of all being flat and ray-like, as in the ordinary form. In the normal form the heads open early in the morning, but on bright days they are closed again by noon, while in the quilled variation the heads remain open several hours longer and never completely close. Hence there is a marked difference in the physiological reactions of the two forms. Another variation is in the color of the rays, which are usually dark yellow; but occasional plants occur in which all the rays are pale lemon yellow. Again, the stems are usually green, but occasionally reddish throughout. There are also great differences in size, which are very probably genetic in nature. The shortest plants are slender and only 18 inches high; while the tallest are very stout, differ in their branching, have much larger leaves and reach nearly 5 feet in height. Other differences can also be observed, indicating that a considerable number of genetic variations exist in this interbreeding population. It is not known whether similar variations occur in this species in its natural European home.

FORREST SHREVE,
Secretary-Treasurer

SOCIETIES AND ACADEMIES

THE AMERICAN MATHEMATICAL SOCIETY

THE one hundred and eighty-sixth regular meeting of the American Mathematical Society was held at Columbia University on Saturday, October 28, extending through the usual morning and afternoon sessions. The attendance included thirty-nine members. President E. W. Brown occupied the chair. The council announced the election of the following persons to membership in the society: Mr. A. C. Bose, Calcutta, India; Professor L. C. Emmons, Michigan Agricultural College; Professor A. M. Harding, University of Arkansas; Dr. W. L. Hart, Harvard University; Dr. J. R. Musselman, University of Illinois; Mr. S. Z. Rothschild, Immediate Benefit Life Insurance Company, Baltimore, Md.; Professor Pauline Sperry, Smith College. Six applications for membership were received.

Committees were appointed to audit the treasurer's accounts and to arrange for the annual meeting in December and the summer meeting of 1917.

The following papers were read at the October meeting:

Mrs. J. R. Roe: "Interfunctional expressibility problems of symmetric functions."

E. D. Roe, Jr.: "A geometric representation."

E. D. Roe, Jr.: "Studies of the Kreisteilungsgleichung and related questions."

E. D. Roe, Jr.: "The irreducible factors of $x^n + x^{n-1} + x^{n-2} + \ldots + 1$."

H. B. Mitchell: "On the imaginary roots of a polynomial and the real roots of its derivative."

J. H. Weaver: "Some properties of parabolas generated by straight lines and circles."

F. N. Cole: "Complete census of the triad systems in fifteen letters."

O. E. Glenn: "Translation surfaces associated with line congruences."

O. E. Glenn: "Methods in the invariant theory of special groups, based on finite expansions of forms."

R. L. Moore: "A theorem concerning continuous curves."

J. R. Kline: "The converse of the theorem concerning the division of a plane by an open curve."

H. S. Vandiver: "Note on the distribution of quadratic and higher power residues."

H. S. Vandiver: "The generalized Lagrange indeterminate congruence for a composite ideal modulus."

The annual meeting of the society will be held at Columbia University on Wednesday and Thursday, December 27–28. At this meeting President Brown will deliver his retiring address, on "The relation of mathematics to the natural sciences." A regular meeting of the society will also be held in Chicago December 22–23. The San Francisco Section will meet at the University of California on Saturday, November 25. The Southwestern Section will meet at the University of Kansas on Saturday, December 2.

F. N. COLE,
Secretary