undeniable facts of accurate observation. The rest of the summary is devoted to showing how these articles dove-tail together in mutual confirmation.

Part II. describes what the author calls 'Non-natural Features,' by which he means those which have the least analogy to features on the earth, and which differ most from what our terrestrial experience would lead us most naturally to expect. In this category he places the canals, and describes their system and their gemination, and presents arguments to substantiate their objectivity as opposed to the diplopic, or the interference, or the illusion theory. A full account of the double canals is given, also of the canals in the dark regions, of the oases, of the 'carets' on the borders of the great diaphragm; and a description of Lampland's success in photographing thirty-eight canals, the doubling of Nilokeras and a snowfall, together with the more prominent 'continents,' 'seas' and 'oases.'

Part III. deals with the 'Canals in Action,' under the headings Canals: kinematic, Canal Development Individually Instanced, Hibernation of the Canals, Arctic Canals and Polar Rifts, Oases: kinematic. The purpose of this section and also of Part IV. is to show that the canals are real water arteries for the distribution of the melting polar caps to the arid equatorial regions, and to the constitution and purpose of the canals and oases in this scheme, with arguments in support of the hypothesis that life, sentient and vegetable, does exist on Mars.

The book is copiously illustrated, and closes with an index of nine pages.

Herman S. Davis

## SOCIETIES AND ACADEMIES

### THE TORREY BOTANICAL CLUB

The second stated meeting for the year 1907 was called to order at the Museum Building of the New York Botanical Garden at 3:30 o'clock P.M. on January 30, 1907, with Vice-president Professor L. M. Underwood in the chair. Twenty-three persons were present.

The scientific program was as follows:

*Experiences on the Island of Jamaica during the Earthquake of January 14, 1907:* Dr. M. A. Howe.

A trip for the collection and study of marine algæ and other plants brought Dr. Howe to the island of Jamaica on December 14, and he was on the island during the recent earthquake. An interesting account was given of his experiences at that time

*New or Rare Mosses from Jamaica:* Mrs. N. L. Britton.

Mrs. Britton exhibited some of the most interesting mosses collected in Jamaica, showing several genera and subgenera, not heretofore known in the West Indies, and several new species, and also indicated some reductions of names to synonyms. Specimens of types of Jamaican species were also shown from the Mitten Herbarium and one of Miss Taylor's drawings of a new species and subgenus.

*The Probable Function of Tannin in Galls:* Dr. Melville T. Cook.

The origin, chemistry and uses of tannin have been studied very extensively, but other phases of the subject have received comparatively little attention. This is especially true concerning the functions which it serves in the plant. It is usually very abundant in diseased tissues, such as insect galls, fungus galls, fungus spots, etc. In insect galls it is developed very early and in some cases it appears to result in the gall-makers moving to other parts of the plant. It is also formed in fungus-galls, frequently completely surrounding the point of rupture. In such fungus spots as those produced by *Cercospora* the successive circles are due to the depositing of tannin within the tissues. The author has made extensive studies on the anatomy of both insect and fungus galls and is now conducting a series of physiological experiments.

C. Stuart Gager,
*Secretary*

## SPECIAL ARTICLES

### THE LIMITATIONS OF ISOLATION IN THE ORIGIN OF SPECIES

Any adequate consideration of the bearing of the geographical distribution of organisms

upon the problems of evolution, especially of the origin and preservation of incipient species, should take into consideration all types of environment and all groups of organisms. The discussion which has continued for some time in the pages of this journal with especial reference to the significance of isolation on the origin of species has drawn its data very largely from the distribution of land and fresh-water vertebrates and has been in the main carried on by systematists who are specialists in these fields. But no insignificant part of the total organic evolution and specific differentiation has been accomplished in other phyla and in other environments. The data of distribution from the littoral, pelagic and abyssal areas of the sea, of the microfauna and flora of fresh water, and of the lower as well as the higher groups of organisms, from widely ranging as well as narrowly limited species and especially from groups in which a high degree of specific differentiation has been attained, such, for example, as the Diatomaceæ, the Radiolaria and the Coleoptera, all have some bearing on the problem unless, as some of the physiological school would have us believe, all wisdom is derivable only from pedigree cultures.

Some familiarity with the microfauna and flora of fresh water and with the pelagic fauna of the Pacific has brought to my attention a series of facts which, with considerable uniformity, indicate a degree of *coincident distribution of related species* which stands in strong contrast with the wide-spread isolation of related species and subspecies of birds and mammals to which attention has been drawn in previous discussions.

The range of material available for demonstration of this tendency is indeed great. The stimulus of the Kiel school of planktologists has led to the investigation of scores, if not hundreds, of lakes and streams, and the publication of extensive lists of their fauna and flora. Recent oceanic explorations in the several oceans have thrown a flood of light on the distribution of pelagic organisms.

The investigation of the microfauna and flora of fresh water, both limnetic and littoral, has demonstrated that its constituent organisms are to a very large degree cosmopolitan. As an illustration of this fact one has but to compare the lists from various localities. The abundant species are very widely represented. The number of rare species reported from any locality is largely a function of the thoroughness and the extent of the examination. About 50 per cent. of the protozoa and rotifers reported from the Illinois River have also been reported from the Elbe, and about 60 per cent. of the rotifers from the Oudy. The differential species, barring a considerable percentage resulting from synonymy, are almost wholly of known wide range but of relative rarity, and may be expected in most aquatic environments of the north temperate zone on long search. As a result of this cosmopolitan distribution most of the known species of a genus are wont to be found in a single locality. An excellent illustration of this phase of the question appears in Penard's splendid monograph of the fresh-water Rhizopoda in which he lists, from Geneva alone, 216 of the 232 known species of this group, and 91 of these from a single locality! He found certain recognizable habitats, each with its more or less peculiar fauna, such, for example, as the sphagnum, the sylvicolous, and abyssal faunas. These include, however, only forty-nine species limited to any special habitat. The genus *Difflugia,* for example, with thirty-seven species, has but nine whose distribution is restricted to a particular habitat; the others may occur in any type of habitat.

In the autumnal months from September to November, streams and lakes rich in organic matter exhibit a marked increase in the ciliate protozoa, especially of the Holotricha. This is especially marked in the Illinois River, and at such times many species of the genera *Prorodon, Lionotus, Lacrymaria, Didinium, Coleps, Nassula* and *Chilodon* occur coincidently. Species of other genera of ciliates such as *Stentor, Euplotes, Vorticella, Zoothammium* and *Epistylis* occur coincidently at this season. Thus Dr. Volk has recently found in the Elbe from September 9 to October 11, 73 per cent. of the *total* number of valid species, of the genera above named,

admitted by Bütschli in his Thierreich monograph. The species which Dr. Volk lists from the Elbe near Hamburg exhibit a high degree of coincident distribution. His data indicate that about 85 per cent. of the recorded species in the genera named are found in the *same* habitats and that 80 per cent. of these were taken at some time in the period named on the same day. Within the genus *Vorticella,* represented by eighteen species, the average percentage of coincident occurrence on the same day in all the collections was 50 per cent.; in *Stentor,* 75 per cent. Among these instances of coincident distribution of the species of a genus are numerous cases of the *coexistence of the most closely related species in the same habitat.*

The fresh-water Rotifera are notoriously cosmopolitan in distribution. About 92 per cent. of the 246 species reported by Professor Jennings from the United States are found on other continents. The species of the group exhibit in common with the fauna and flora with which they are associated, certain well-defined restrictions in distribution, due to environmental factors combined in various types of habitat, such as open water, and shore vegetation. The genus *Brachionus* is found predominantly in open water of warm shallow ponds and streams where it occurs in enormous numbers during a large part of the year. After eliminating synonyms arising in large part from failure to examine literature or to ascertain the seasonal form-cycle, there remain at least about twelve common forms of specific value in this genus along with a considerable number of so-called variants. One of these species, *B. dorcas,* is predominantly a winter species, and another *B. militaris,* predominantly a shore and vegetation-loving species. The remaining forms are all typical members of the limnetic fauna of warm shallow waters and *usually together throughout a large part of the summer,* in many parts of the world. In common with practically all other organisms of the limnetic fauna and flora these species of *Brachionus* run a rhythmical course of fluctuating recurrent cycles of increase and decrease in numbers of three to six weeks' duration. A single instance drawn from the records of the Illinois State Laboratory of Natural History of my unpublished statistical work upon the plankton of the Illinois River will suffice to illustrate the character of these rhythmical fluctuations and the relations which they bear to the breeding periods of *Brachionus.* During the rise of the 'pulse,' parthenogenesis prevails, and at its maximum and during its decline sexual reproduction appears as indicated by the presence of male eggs, males and winter eggs. The imperfections of the plankton method, the difficulty of specific identification of male rotifers and detached eggs introduce a considerable degree of incompleteness in these statistical records. The trend of the statistics remains, however, significant.

BRACHIONUS ANGULARIS.—NUMBER PER CUBIC METER ILLINOIS RIVER, 1896.

| Date. | Females with Parthenogenetic Eggs. | Females with Male Eggs. | Females with Winter Eggs. | Males. | Total, Eggs and Adults. |
|---|---|---|---|---|---|
| July 29 | 4,560 | 0 | 0 | 0 | 27,072 |
| Aug. 1 | 7,747 | 0 | 0 | 0 | 69,342 |
| Aug. 8 | 18,696 | 0 | 0 | 0 | 81,320 |
| Aug. 12 | 29,106 | 103,950 | 594 | 0 | 773,982 |
| Aug. 21 | 9,496 | 3,561 | 0 | 1,187 | 161,432 |
| Aug. 29 | 3,775 | 0 | 0 | 0 | 28,355 |
| Sept. 5 | 2,385 | 0 | 0 | 0 | 16,536 |

Within the breeding period of *B. angularis* covered by this table, *Brachionus pala, B. amphiceros, B. bidens* and *B. bakeri* were also found with male or winter eggs or both, and *B. cluniorbicularis, B. melhelmi, B. militaris, B. mollis, B. punctatus, B. rhenanus, B. rubens* and *B. tuberculus* ran a like cycle of smaller amplitude, but no males or winter eggs were found attached to the individuals counted. No effort was made during the collection of these statistics to determine whether these remaining species were breeding sexually or not. It is quite possible that they were. The list includes a number of instances of most closely related couplets. Opinions differ as to the specific, subspecific or varietal standing of some of the forms in the list.

We have then in *Brachionus* coincident distribution of nearly all the species of the genus

and contemporaneous sexual reproduction in five species or varieties, in this instance, with the possibility that the remaining eight may also be in sexual activity. There is little possibility of any horizontal stratification separating the species here, as the waters of the Illinois River are shallow (three to ten feet) and are stirred by current and diurnal movements. These same species occur together, moreover, in shallow bottom-land lakes but a few inches in depth.

Closely related species and varieties of *Brachionus* thus live together in the same habitat and breed at the same times, with no external barriers to prevent their swamping out.

The fresh-water Copepoda afford an excellent test for the contemporaneous breeding of closely related species having coincident distribution, since the eggs are carried for some time by the female during their development and the breeding periods of the several species can thus be determined. There are six species in the subgenus *Cyclops* which occur in the Illinois River and are often found breeding in the same seasons. Two of the most closely related, *C. edax* Forbes and *C. leuckarti* Claus, are found breeding coincidently in August. The other members of the subgenus, *C. viridis* Jurine and *C. bicuspidatus* Claus have overlapping breeding periods in the spring, and the two varieties of *C. viridis,* v. *insectus* Forbes and v. *brevispinosus* Herrick breed coincidently throughout the summer. *C. serrulatus* Fischer and *C. prasinus,* closely related species of the subgenus *Eucyclops* have a wide distribution in the United States and Europe and are frequently found in the same collections. *Diaptomus pallidus* and *D. sicilioides,* two most closely related species of Calanidæ, are found together in about equal numbers, breeding at the same seasons in the Illinois River.

The limnetic fauna and flora thus afford numerous instances not only of the coincident distribution of closely related species, but as well of their contemporaneous breeding. The extent to which this factor of contemporaneous breeding prevails among the organisms of fresh waters and the full force of its bearing upon the problem of isolation are best understood when the fact is borne in mind that the whole ensemble of organisms constituting the plankton, runs throughout the year, year in and year out, this rhythmical series of recurrent cycles. In this most, if not all, of the constituent plants and animals have coincident periods of rapid increase followed by one of subsequent declines offering, in cases of sexual reproduction, repeated opportunities for the interbreeding of related forms, and the swamping out of incipient species arising by the slow accumulation of minute fluctuating variations. There appears, however, to be no lack of specific differentiation among these organisms. Isolation by external factors seems to play a small part, if indeed any, in specific differentiation in this type of habitat.

The pelagic life of the sea abounds in seeming instances of the coincident distribution of closely related species in an environment presenting a minimum degree of diversification and a relative absence of barriers. The incompleteness of our knowledge of the horizontal and vertical distribution of pelagic organisms and of their breeding seasons leaves here much to be desired in the data for a discussion of this problem. There is great specific differentiation among pelagic diatoms, Radiolaria, Foraminifera, Dinoflagellata, Copepoda and Amphipoda. Frequently many species of the same genus occur in the same region, witness the fifty species of *Coscinodiscus* found by Karsten in the Antarctic plankton of the Valdivia Expedition, largely at a depth between 60 and 40 meters.

The genus *Ceratium* of the dinoflagellates is one of the most diversified and its species are among the most variable of marine organisms and are mainly of wide distribution. In the plankton of the Pacific immediately at the surface, that is in the upper 2–3 meters, it is no unusual thing to take 25–30 species in a single 14-inch net.

There are three species of *Ceratium* which are usually coincidently abundant in the Pacific off San Diego which are most closely related, so closely in fact that their distinctness has frequently been overlooked by casual

workers on this genus. They are the cosmopolitan *C. furca* (Ehrbg.), and *C. lineatum* (Ehrbg.), and the minute *C. eugrammum* (Ehrbg.). The species are evidently closely related, differing only in certain proportions of the midbody, in the degree of ventral excavation and in size. The examination of a wide range of material and a statistical study of their proportions has convinced me of their distinctness. Their resemblances are so plainly marked that one is forced to conclude that they are branches of a common stem or co-mutants. *C. furca* and *C. lineatum* are widely distributed in temperate and tropical seas and the occurrence of *C. eugrammum* in both the Mediterranean and in the Pacific is suggestive of a similar range. Its small size enables it to slip through the mesh of even a fine plankton net. This fact, together with its resemblance to *C. lineatum,* doubtless explains its comparative absence in published records of distribution. These species are abundant at the same seasons, and are taken repeatedly at the same levels in the same net. Their pelagic habit is suggestive of a pelagic origin and their coincident distribution over wide areas would seem to afford abundant and oft-repeated opportunities for swamping out incipient species by interbreeding of the diverging forms with parental stock, provided their origin took place by the gradual accumulation of minute fluctuating variations.

The lists of plankton organisms in European seas published by the Conseil permanent pour l'exploration de la mer, as well as our records for the past four years at San Diego, show many instances of the coincident distribution of *Ceratium macroceros, C. longipes,* and *C. intermedium,* three closely related species, all having open tips to the antapical horns and more or less postindentation, but differing from each other in size, form of the shoulders and the angular divergence of the horns. These species are so closely related that they have been much confused in the past, but our best specialists in this group are now agreed that the species are distinct. They are the most closely related species of their section of the genus to which they belong and they have a coincident and apparently coextensive distribution in temperate seas.

Another striking instance of coincident distribution is found in the species of the *C. tripos* group, including the closely related *C. azoricum, C. arcuata, C. heterocamptum, C. bucephalum* and *C. curvicorne,* which are very often found together in the plankton of the Pacific and extensively throughout much of the Atlantic as Cleve has shown in his 'Seasonal Distribution of Atlantic Plankton Organisms.'

Dividing twenty-seven of the more common species of *Ceratium* in groups of most closely related species and determining their distribution in surface waters of the Pacific in twenty-one typical collections, we find that the percentage of coincident distribution of the species of the several groups actually realized in the collections ranges from 48 per cent. to 68 per cent. on an average.

Unfortunately for my discussion, we know neither the strata nor the seasons in which the sexual reproduction of these organisms occurs, if, indeed, any exists.

It will doubtless be suggested by defenders of the universal potency of isolation in the origin of species that the instances of coincident distribution of related species which I have here cited are those of organisms which multiply predominantly by asexual methods or at least by parthenogenesis, that sexual reproduction is entirely, or at least relatively, absent and that this in itself constitutes an effective isolation and prevents the swamping out of new forms. In reply to this attention should be directed to the admirable researches of Dr. Schaudinn and of Professor Richard Hertwig, and especially to the results of investigations into the life histories of the *Sporozoa* and the *Foraminifera* which have brought to light the wide-spread occurrence of typical sexual reproduction in so many of the protozoa. So striking have been these results that it is safe to say that a full knowledge of life histories will reveal sexual reproduction in all protozoa. Over against the apparent infrequency of sexual reproduction in the protozoa and many fresh-water organisms should be placed the brevity of the life cycle and the considerable

number of sexually produced generations which are possible every year. *Polyarthra platyptera,* a common cosmopolitan rotifer, produces, in the Illinois River, male and winter eggs throughout most of the year at the close of parthenogenetic cycles of 3–6 weeks duration. It is not improbable that other organisms of the same habitat run a similar course and exhibit a corresponding proportion of sexual reproductions. Opportunities for swamping out incipient species are present, therefore, in these organisms, at least in so far as the existence of sexual reproduction offers them, in limnetic and pelagic organisms as well as in the fauna and flora of the land or in animals of higher organization. The work of Maupas and Calkins on the recurrence of conjugation in ciliates is significant as indicating the necessity of sexual reproduction among unicellular organisms.

Evidence of the coincident distribution of related species of higher pelagic organisms in which amphigony is the only form of reproduction may be found among the chætognaths. Other groups of pelagic organisms should be examined on this point. The publication of Fowler's excellent monograph on the chætognaths in the reports of the "Siboga" expedition, in which he reviews the matter of their distribution, affords some pertinent data of prime significance because the group is a sharply circumscribed one with but few species, the distribution of most of which is fairly well known. There are but three genera, *Sagitta, Krohnia* and *Spadella* in which the author recognizes twenty, three and two species, respectively. The two species of *Spadella* are members of the epiplankton and their areas of distribution overlap. In the case of *Sagitta* there are twelve species which belong to the epiplankton of warm temperate and tropical waters. In this group are both cosmopolitan and apparently restricted species. The remaining eight species belong to colder or deeper waters (5) or are of undetermined range (3). Of the twelve species at least ten are known to occur in the Indo-Australian or Indo-Pacific regions, where they exhibit coincident or overlapping distribution.

The species of *Sagitta,* though relatively few in number, are often so similar in structure as to be separated with great difficulty even by a specialist. One of the most closely related groups in the genus is that formed by *S. serratodentata,* a cosmopolitan eurythermal species ranging in the epiplankton from the latitude of the Straits of Magellan to the equator, and by *S. bedoti, S. ferox* and *S. robusta* from the epiplankton of the Indo-Pacific region. These four species occur together *repeatedly* in the Siboga collections of surface plankton. A second group of related species is formed by *S. enflata, S. hexaptera* and *S. pulchra* which likewise occur together in the same collections often in large numbers. The first two species of this section are ones of wide range and the last an Indo-Austral one.

*S. neglecta* and *S. regularis,* two closely related neritic species from the Malay Archipelago, form a third group having a coincident distribution. There are possibly two instances, *S. furcata* and *S. planctonis,* and *S. bedoti* and *S. sibogæ,* where related species have a contiguous distribution in epiplankton and mesoplankton. The data are too scanty for definite conclusion.

It appears from Fowler's records that, as a rule, the *most closely related* species of this genus have, not a *contiguous,* but a *coincident* distribution. In the present condition of our knowledge it is impossible to state whether these species breed at the same seasons or not. Shipley in the Cambridge Natural History states that *Sagitta* breeds throughout the year. Fertilization is presumably external in many species, though known to be internal in one and eggs are pelagic, but there are no geographical barriers which intervene to prevent the swamping out of incipient species. Provided there are in these related species of *Sagitta,* no differential breeding seasons, and no differential levels or temperatures at which extrusion of ova and sperm occur, no assortive assemblings of the individuals of the given species during specialized breeding seasons and no close fertilization, we are compelled to fall back upon the assumption of a sterility of the cross between an incipient species and

its parent stock or preferential mating of like forms for an explanation for the origin and continuance of these closely related species in a coincident environment. This is the solution which Darwin proposed to meet this difficulty. De Vries finds that the *coincidently* appearing new elementary species of *Œnothera* attain their full constancy at once. Isolation plays no part in their origin or continuance.

Charles Atwood Kofoid
University of California

## NOTE ON A TERTIARY BASIN IN NORTHERN ALASKA[1]

Beds of Tertiary age are known in various widely separated regions of Arctic and sub-Arctic America. They occur generally in basins of limited area in the older rocks. Such basins are rather widely distributed in Alaska. Brooks[2] has recently reviewed the literature relating to those in Alaska. A number of isolated Tertiary basins are known in the islands of the Arctic Archipelago[3] and others have been reported in the Northwest Territory[4] east of northern Alaska. The age of nearly all of the Tertiary beds which are known in Arctic America has been determined from plant remains occurring in them, so that we have a very fair knowledge of the plant life of northern America in Tertiary times, but a very meager knowledge of the invertebrate fresh-water fauna which lived in some of the Tertiary lakes of Arctic America. The discovery of such a fauna by the writer during the past summer along the Porcupine River in northeastern Alaska seems, therefore, worthy of record.

About one hundred miles above its junction with the Yukon the Porcupine River enters the Yukon Flats, an alluvial plain without topographic relief, through which the Yukon River flows for 200 miles. Before entering the Yukon Flats the Porcupine traverses for about 25 miles a belt of limestones of Paleozoic age having a north and south trend and giving rise to low mountains and hills. Between this belt of elevated country and a similar but wider zone of topographic relief near the international boundary extends a comparatively flat basin having a width of about 25 miles. The north and south extent of this basin, which Maddren has called the Coleen Basin,[5] after the river draining its northern portion, is unknown. There is good reason to believe, however, that its north and south extent is much greater than its width. The Porcupine traverses this basin in wide sweeping meanders. The migration of the channel of the river along parts of its course through this basin has left in places low banks bordered by recent silts. An older set of sediments, however, constitutes the bulk of the floor of the Coleen Basin. These older sediments are well exposed on the largest meander in this portion of the river, known as the Fish Hook bend, which shows continuous bluffs for two or three miles, 40 to 100 feet high, composed mainly of finely laminated shale or clay. The dominant color of these beds is light lemon yellow, which is varied by patches of yellowish green, pink, and brownish. At the upper end of Fish Hook bend, on the west bank of the river, the following section was measured:

| | Feet. |
|---|---|
| 1. Fine sand, soil and muck (top) | 1– 5 |
| 2. Coarse gravel and sand | 10 |
| 3. Dark carbonaceous clay and old forest bed | 0– 2 |
| 4. Coarse gravel and sand | 15 |
| 5. Soft, finely laminated, drab-colored clay shale, with large ironstone concretions in upper part, containing fresh-water bivalves | 70 |

The fossils which were secured from the ferruginous concretions occurring in divi-

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

[2] 'The Geography and Geology of Alaska,' professional paper U. S. Geological Survey, No. 45, pp. 237–244, 1906.

[3] Low, A. P., 'Cruise of the Neptune,' 1906, pp. 226–229.

[4] McConnell, R. G., 'Report on an Exploration in the Yukon and Mackenzie Basins, Northwest Territory,' Can. Geol. Surv., Vol. 4, n. ser., Rept. D, 1890.

Camsell, C., Report on the Peel River and Tributaries Yukon and Mackenzie, Can. Geol. Surv., Vol. XVI., 1906, Pt. C, pp. 27–28.

[5] 'Smithsonian Exploration in Alaska in 1904 in Search of Mammoth and other Fossil Remains,' *Smithsonian Misc. Coll.*, Vol. 49, 1905, p. 12.