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W. H. WAGNER, JR. and F. S. WAGNER

Research supported by N.S.F. Grant GB-2025, "The Evolutionary Characters of Ferns." In addition to the persons mentioned in the text, we are grateful to Doctors E. T. Wherry, R. C. Benedict, and Stanley Walker for their helpful letters, and to the Project Assistant, Katherine Lim Chen, for aid in the greenhouse and laboratory.

Among the most conspicuous genera of ferns in the woodlands and swamps of eastern North America is the genus of Woodferns, **Dryopteris.** These large and showy plants include a total of some 12 basic species (not counting the seven species formerly included but now placed in other genera). Some of the woodferns make fine outdoor-garden plants. Recently, the variation and evolution of the genus **Dryopteris** has provided an interesting subject for cytogenetic research. The genus invites special attention for the ability of its species to form natural hybrids, some of which have changed into fertile species themselves and others of which have apparently remained sterile but produce large colonies nevertheless. The following is a report of research that was carried out in 1964 on an unusually interesting collection of woodferns found growing wild in the vicinity of Rochester, New York.

Of American woodferns, one of the most poorly known is the Log Fern, **Dryopteris celsa** (W. Palmer) Small. Palmer (1902) discovered the plant originally in the Dismal Swamp of Virginia, growing on bases of large trees and partially rotten logs. This is a striking and beautiful fern, differing from the related and equally attractive Goldie's or Giant Woodfern, **D. goldiana** (Hook.) Gray, in being more erect with narrower fronds, the apex regularly decreasing instead of being crowded and suddenly shortened. Log Fern differs from what is traditionally identified as Clinton's Woodfern, **D. clintoniana** (D. C. Eat.) Dowell, particularly in its broader, somewhat more ovate basal leaflets, the slightly tan-scaly midrib, and darker, glossier scales on the rhizomes and petiole bases. In the Great Lakes area the Clinton's Woodfern is generally considered to be the most common and characteristic swamp species of this group, along with the Crested Woodfern, **D. cristata** (L.) Gray, a smaller, much more narrow-leaved fern. Good descriptions and illustrations of all of these ferns can be found in Wherry's *Fern Guide* (1961).

For a long time the true status of Log Fern was undetermined; and it was not until the recent extensive studies of Stanley Walker of the University of Liverpool (1962) that its cytogenetic differences from its near relatives were recognized and described. Walker found in his investigations that **D. goldiana** has $n = 41$ chromosomes, **D. celsa** has $n = 82$, and **D. clintoniana** has $n = 123$; and there are, therefore, important differences at this level between these species in addition to the known distinctions at the gross, morphological level.

Partly because of its frequent confusion with its near relatives, and partly because of its actual rarity in many localities, our knowledge of the distribution of the Log Fern has been vague. As recently as 1950, the Harvard University botanist, M. L. Fernald, described its distribution as "on or near Coastal Plain, La. to S.C., n. to se. Va. and locally to se. Pa." Stanley Walker (op. cit., p. 503) was one of those who suggested that **D. celsa** or its hybrids might occur further north; he found cytogenetic evidence of the existence of **D. celsa** or some of its hybrids even as far north as New Jersey. Also, Benedict (1954) encountered some suggestive specimens of either **D. celsa** or the similar **D. clintoniana** X **goldiana** hybrid near Pilot Knob, New York. Nothing in the published history, however, anticipated the finding of Log Fern in abundance in localities as far away as Rochester, New York, between 200 and 250 miles away from its assumed range, and in one of the botanically best known sections of the United States. Around Rochester Log Fern has now been found in the phytogeographical region south of Lake Ontario where its existence could hardly have been predicted on the basis of our past knowledge. The circumstances behind this discovery will be outlined here, as well as a number of noteworthy consequences of our investigation.

BACKGROUND

During the course of a survey of dried herbarium material of the genus **Dryopteris** kindly supplied by the curators of the U. S. National Museum, the New York Botanical Garden, and the Philadelphia Academy of Sciences, our attention was drawn to the elaborately labeled specimens of so-called "**Dryopteris cristata** (L.) Gray var. **clintoniana** (D.C.Eat.) Underw.," that comprise no. 1301 of the *"Plantae Exsiccatae Grayanae"*, a series of collections issued in many duplicates and distributed to herbaria by Harvard University. As well as we could judge the species represented by exsiccate no. 1301 could be nothing, in our opinion, but true Log Fern, **D. celsa.** However, the printed locality data on these duplicated herbarium sheets seemed very unlikely: "thickly wooded, swampy area 3 miles west of Riga, Monroe County, New York. Coll. W. A. Matthews (no. 4748), September 14, 1945." So far away from its known range did this locality seem that we doubted our own identification, and we were compelled, therefore, to make a further check to see whether this could indeed be the Log Fern.[1]

A helpful test of identification can be derived from the spores. Samples of spores from **D. celsa** generally average in length, as measured for exospore length under the microscope on slides mounted in diaphane, between 36 and 42 microns. Those of **D. clintoniana,** which the Harvard University botanists construed as a "variety" of the Crested Fern, **D. cristata,** are definitely larger, averaging usually between 45 and 50 microns. When we checked the spores of the Rochester area collection, their measurements clearly confirmed the smaller size that is diagnostic of Log Fern.

To check still further we planned a field trip to the Rochester area, and we wrote to Dr. R. E. Stauffer describing our study and requesting aid from him and the botanists of that city to find the original Matthews' locality. For the most objective identification of native woodferns, taxonomists must use a combination of observations from morphology (the details of leaf form especially), anatomy (the presence of distinctive hairs or glands, and the structure of the scales, especially), palynology (spores, especially their size, and whether or not they are abortive, a characteristic of sterile hybrids in this genus), and cytology (specifically the chromosomes) to arrive at the most convincing evidence. This tedious procedure applies, of course, only to "problem" identifications—most wood-fern species and many of the hybrids are readily recognized by simple, gross distinguishing features, as most botanists know, and they need little more than a glance. The basic set or complement of chromosomes in the genus **Dryopteris** is $x = 41$, as revealed in the studies of Walker. The chromosomes, given a good, standard microscope, are usually easy to count if cells which are undergoing division are properly squashed and stained. A photograph of a typical "squash" is shown in Figure 1 of the chromosomes of **D. celsa** X **cristata** with 28 pairs of chromosomes and 108 single chromosomes. It will be noted that a photograph made at high power can rarely show all of the chromosome configurations clearly and at the same focus, for obvious reasons. That is why botanical readers find so few, otherwise excellent, published photographs which can be interpreted with precision. Most taxonomists now maintain permanent slides of the actual cells which they lend to their colleagues if questions of interpretation happen to arise, and such slides are available for the work reported here. The chromosome interpretations illustrated in Figure 2 were drawn by using a camera lucida device on the micro-

1. We should note that Professor E. T. Wherry had earlier suspected this identity of the Gray Herbarium exsiccate but he did not publish this, having been given what has since proved to be an erroneous spore analysis.

scope and carefully adjusting the focus so as to see the outlines of each pair and single. The data given in Table 1 were obtained the same way.

Because of our need to check the "problem" plants from Rochester area as thoroughly as possible, we collected not only sample dried fronds during our stay there, but we also took back living rhizomes (over 4 dozen) by airplane to Ann Arbor, where we grew them in the greenhouses of the University of Michigan Botanical Gardens until they produced new fronds and reached the proper stages of cell divisions and spore formation.

We wish to thank all of those Rochester botanists who made this work possible—Dr. and Mrs. E. T. Boardman, Professor Babette B. Coleman, Mr. Clair Smith, and Mr. Bernard Harkness; and especially Dr. and Mrs. Stauffer, who coordinated the over-all field study. The voucher specimens to document this research will be deposited in the Herbarium of the University of Michigan, and duplicates will be sent to the Rochester Museum and other herbaria.

RESULTS OF THE FIELD AND GREEN-HOUSE INVESTIGATION

"Riga Swamp"

This locality is as follows: New York: Monroe Co., 1 mi. e. of Genesee Co. line, along route NY33A, Mr. Pym's property (April 18, 1964). This swamp was as near to what was the likely original Matthews' site as Dr. Stauffer could determine. The low, rich, damp woodland has a heavy ash, elm, and maple cover, and the ferns in question develop here in great luxuriance. We easily found the Log Fern, **D. celsa,** in abundance, but the leaves at that time of year were lying flat on the ground. A typical leaf from "Riga Swamp" is shown in Figure 3, C. The fronds were all evergreen or nearly so, making it feasible to prepare good, pressed specimens. As listed in Table 1, samples from 14 colonies all yielded the expected 82 pairs of chromosomes when they were later examined in Ann Arbor, thus confirming our identification. (A few showed early disjunction of the pairs, but this is a common phenomenon in ferns). Thus from "Riga Swamp" alone we were able to establish that the chromosome number was like that of typical **D. celsa** from far to the south in Virginia.

As we became more and more familiar during our explorations with the variation of Log Fern, we began to realize that there were many "peculiar" individuals which in leaf cutting, soral position or other characteristics did not conform with the rest. Some of these (and probably all) appeared to be interspecific hybrids involving Log Fern and one or another of the species growing nearby. The common woodferns present in this swamp beside **D. celsa** are the Fancy Fern, **D. intermedia**

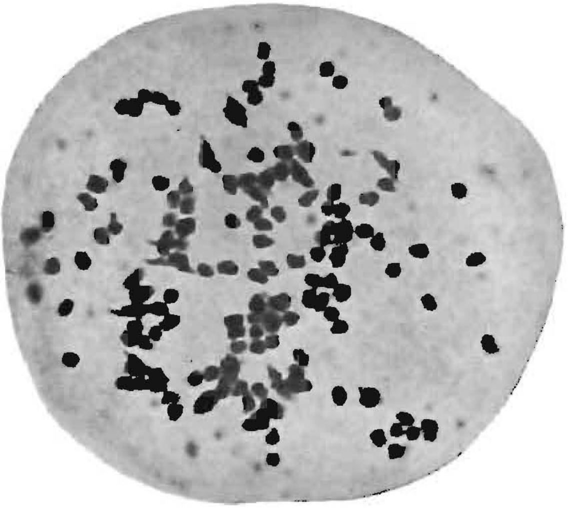

FIGURE 1: Chromosomes of **Dryopteris celsa** X **cristata**, (28) + 108, New York, Genesee Co., "E. Bergen Swamp," 64012-3 (the same cell as drawn in Figure 2, 1).

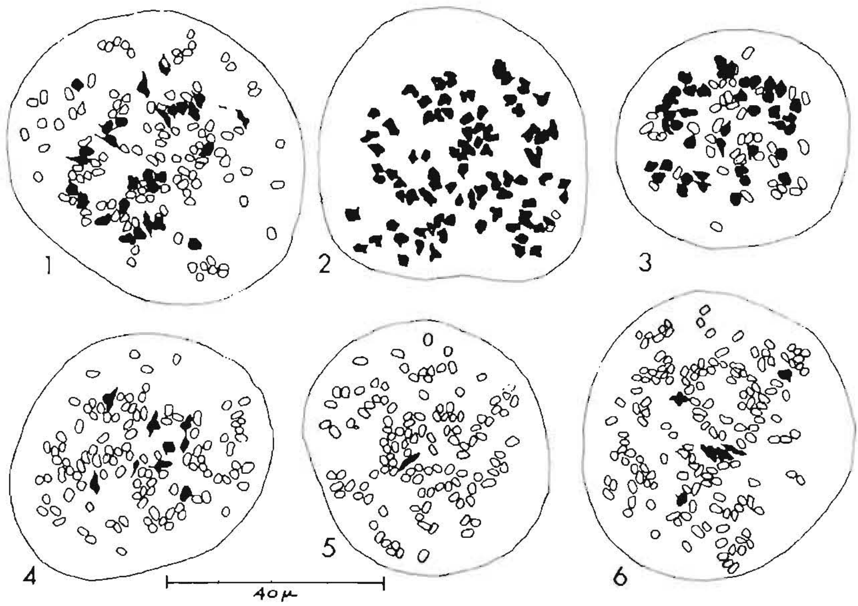

FIGURE 2: Chromosomes of the Log Fern Complex from Rochester, N. Y., area. Nos. of W. H. Wagner, Jr.; vouchers in MICH. 1. **Dryopteris celsa** X **cristata**, (28) + 108 chromosomes, Genesee Co., "E. Bergen Swamp," 64012-3. 2. **D. celsa**, (81) + 2, Monroe Co., "Riga Swamp," 64008-H. 3. **D. celsa** X **goldiana**, (41) + 41, Monroe Co., Henrietta Twp., "Cedar Swamp," 64014-B. 4. **D. celsa** X **marginalis** = **D.** X **leedsii**, (7) + 109, same locality as "2," 64010-2. 5. **D. celsa** X **intermedia** = **D.** X **separabilis**, (1) + 121, same locality as "2," 64011-1. 6. **D. celsa** X **spinulosa**?, (6) + 152, Genesee Co., "Pocock Entrance, Bergen Swamp," 64018.

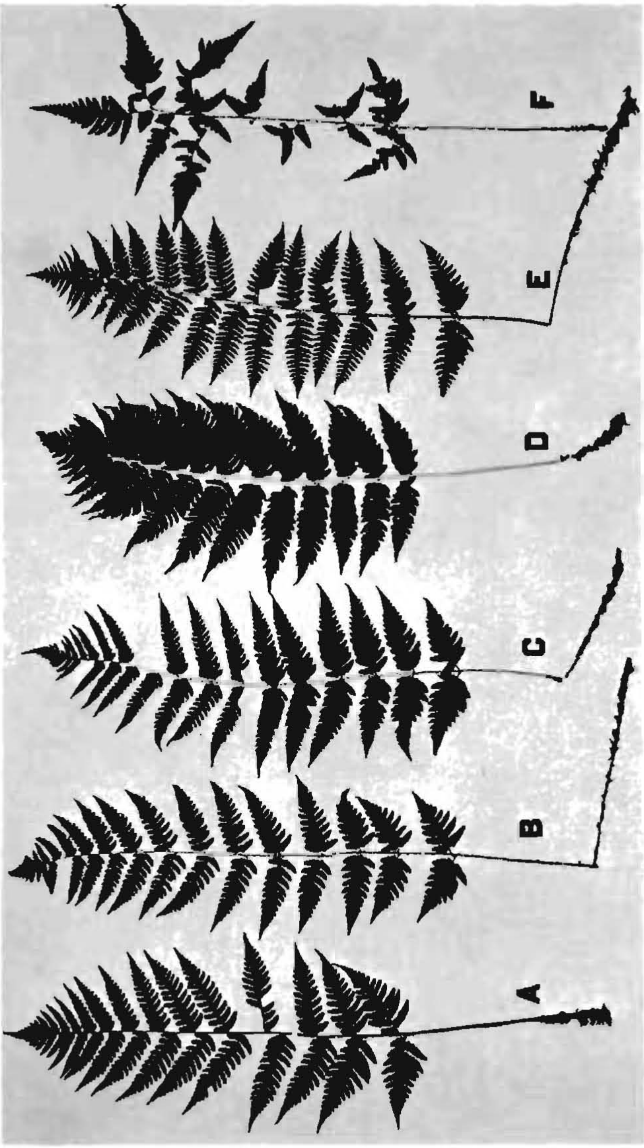

FIGURE 3: Members of the Log Fern Complex from the Rochester, N. Y., area. The largest frond illustrated is "B," which is 90 cm. long, or just short of three feet. All nos. those of W. H. Wagner, Jr., and deposited in MICH. A. **Dryopteris celsa** X **marginalis** = **D.** X **leedsii,** Monroe Co., "Riga Swamp," 64010–4. B. **D. celsa** X **cristata,** Genesee Co., "Pocock Entrance, Bergen Swamp," 64020–3. C. **D. celsa,** same locality as "B," 64020–2. D. **D. celsa** X **goldiana,** Monroe Co., Henrietta Twp., "Cedar Swamp," 64014a-1. E. **D. celsa** X **intermedia** = **D.** X **separabilis,** same locality as "B," 64019–1. F. **D. celsa** X **spinulosa**?, same locality at "A," 64010–6.

(Muhl.) Gray, with its finely dissected, lacy but firm, glandular, and evergreen fronds; and the Marginal Woodfern, **D. marginalis** (L.) Gray, with more coarse, whitish-green fronds, a rather leathery texture, and the sori borne along the leaflet margins. We also saw a few rather poor specimens of Spinulose Woodfern, **D. spinulosa** (O. F. Muell.) Watt; and it is possible that other species which are, like **D. spinulosa**, more or less deciduous may possibly grow here but were not observed because of their inconspicuousness.

Much the most common of these "peculiar" woodferns in this swamp turned out to be **D. celsa** X **marginalis** (Figure 3, A), more familiar as **D.** X **leedsii** Wherry,[2] a fern described originally from Harford County, Maryland, and considered to be a rare and highly localized plant. This discovery in "Riga Swamp" of the numerous splendid plants of **D.** X **leedsii** constitutes the first published record from the state of New York. An additional cross, though not as common, was **D. celsa** X **intermedia** (shown in Figure 3, E), of which Stauffer and Smith recognized the first examples growing in a patch at the base of a tree. Anatomically this Log Fern hybrid is distinguished by the covering of glandular hairs on the indusia (as seen under a high power hand lens), a sure sign of the influence of the glandular species, **D. intermedia**. This hybrid fern, better known as **D.** X **separabilis** Small, is one of our scarcest American woodferns. It has never before been collected north of the latitude of Lake Drummond in the Dismal Swamp of Virginia according to the published record. Our collections of **D.** X **separabilis** are thus not only new for New York state, but they constitute the first authenticated finds from other than the type region, a major range extension of over 420 miles toward the north-northwest.

Several additional Log Fern crosses were discovered, of which at least one (Figure 3, B) has apparently never been illustrated in the botanical literature. Specimens which we thought at the time of collection might be either narrow **D. clintoniana** or broad **D. cristata** proved, upon our later study of the chromosomes, to be **D. celsa** X **cristata.** Oddly, we did not succeed in finding **D. cristata** in "Riga Swamp"; however, this species is deciduous and so could have been easily overlooked. **D. celsa** X **cristata** is distinguishable cytologically from **D. clintoniana** by having 164 chromosomes rather than 246, and by its abortive rather than normal spores. From **D. cristata** which has the same chromosome number, this new hybrid can be separated by its abortive spores, as well as the fact

2. **Dryopteris** X **leedsii** was considered by Professor Wherry (1963) to be **D. goldiana** X **marginalis**; and the taxon known as **D. wherryi** Crane was thought to be the same hybrid with a doubled chromosome number. However, Walker (1962b) found that **D.** X **leedsii** is a triploid (123 chromosomes), not a diploid (82); and Wagner (1963, p. 150), on the basis of a study of the original locality in company with Dr. Wherry, first suggested that **D.** X **leedsii** is probably **D. celsa** X **marginalis.**

that its chromosomes pair up in relatively large numbers (as shown in Figure 2, 1; Figure 1; and Table 1). The significance of this pairing relationship is currently being interpreted by Stanley Walker.

While seeking further variations in "Riga Swamp," we ran across still another "peculiar" woodfern, a plant resembling **D. goldiana** but unlike it at this season in showing mostly evergreen, rather than deciduous, fronds.[3] This plant proved later to be the hybrid **D. celsa X goldiana,** the chromosomes of which (Figure 2, 3; and Table 1) were first described by Walker (op. cit., pp. 500–501) on materials from the latitude of southern Pennsylvania. The weirdest plant collected was that illustrated in Figure 3, F. As nearly as we can guess from its strange morphology it constitutes **D. celsa X spinulosa.** The chromosome number conforms to this hypothesis (Figure 2, 6; Table 1), and the soral position and leaf cutting are not inconsistent with it. However, the odd irregularity is such that it could just as well be an unusual specimen of **D. clintoniana X marginalis,** a fern that has very similar chromosome conditions, but we have no evidence whatsoever of **D. clintoniana** in this swamp.

More of our time was devoted to the exploration of "Riga Swamp" than to any of the others of the localities we visited; but we decided to examine several additional swamps in the region simply to see whether similar combinations of species and hybrids could be found.

"E. Bergen-Byron Swamp"

This place (New York: Genesee Co., Bergen Twp., e. part of Bergen-Byron Swamp, April 18, 1964) was a disappointment. Various woodferns abound here, but we could discover no Log Ferns. The widespread species, **D. intermedia** and **D. marginalis,** were particularly common (in fact we took a sample of their rare hybrid); but we nearly gave up our quest for Log Fern. Ultimately we did find one patch of plants which were identified as narrow "**D. clintoniana**" at the time. When the latter were studied in detail in Ann Arbor later, however, it was revealed that they had sterile spores. The chromosomes turned out to be the same as those of **D. celsa X cristata** from "Riga Swamp." It should be noted that we succeeded in finding neither of the presumed parents in this swamp.

"Cedar Swamp"

At this locality (New York: Monroe Co., Henrietta Twp., near junction of route NY15A and a spur line of Lehigh Valley R.R., April 18, 1964) we encountered a lovely, rich woods where spring flowers of many species flourish, and where there are both loamy hillsides and low, swampy areas. Mr. Clair Smith guided us to the colonies of woodferns known

3. **Dryopteris goldiana** has been stated to be evergreen in certain well-known manuals, but this does not accord with the experience of careful field observers.

Identification	Field No.	Swamp	II's	I's	Total
D. celsa	8a	Riga	82	0	164
" "	8d	"	82	0	164
" "	8e	"	82	0	164
" "	"	"	81	2	164
" "	8g	"	81	2	164
" "	8h	"	81	2	164
" "	8i	"	82	0	164
" "	8j	"	82	0	164
" "	9ab-2	"	82	0	164
" "	9ab-3	"	81	2	164
" "	9ab-8	"	82	0	164
" "	9ab-10	"	82	0	164
" "	9ab-12	"	82	0	164
" "	10-3	"	82	0	164
" "	17-1	Bergen-Poc.	82	0	164
" "	17-2	" "	82	0	164
" "	17-3	" "	82	0	164
" "	17-4	" "	82	0	164
" "	17-5	" "	82	0	164
" "	20-1	" "	82	0	164
" "	20-2	" "	82	0	164
D. celsaXcrist	9ab-1	Riga	33	98	164
" " " "	9ab-4	"	38	88	164
" " " "	9ab-5	"	30	104	164
" " " "	9ab-6	"	38	88	164
" " " "	9ab-9	"	33	97	163
" " " "	9ab-11	"	36	92	164
" " " "	12-2	E. Bergen	27	111	165
" " " "	12-3	" "	28	108	164
" " " "	12-3	" "	40	86	166
" " " "	15	Cedar Swamp	41	83	165
" " " "	16	" "	47	70	164
" " " "	16	" "	42	81	165
" " " "	16	" "	33	98	164
" " " "	20-3	Bergen-Poc.	35	94	164
" " " "	"	" "	36	93	165
D. celsaXgold	8f	Riga	42	39	123
" " " "	"	"	40	43	123
" " " "	14a-1	Cedar Swamp	41	41	123
" " " "	14b	" "	41	41	123
D. celsaXinter	11-1	Riga	1	121	123
" " " "	11-2	"	9	105	123
" " " "	19-1	Bergen-Poc.	2	119	123
" " " "	19-2	" "	6	111	123
D. celsaXmarg	9ab-7	Riga	12	100	124
" " " "	10-1	"	11	101	123
" " " "	10-2	"	7	109	123
" " " "	10-4	"	2	119	123
" " " "	10-5	"	4	115	123
" " " "	10-7	"	2	119	123
D. celsaXspin?	10-6	"	1	162	164
" " " "	"	"	5	154	164
" " " "	"	"	11	143	165
" " " "	18	Bergen-Poc.	6	152	164
" " " "	"	" "	4	156	164
" " " "	"	" "	5	154	164
D. cristataXmarg	20-4	" "	5	114	124

TABLE 1. Chromosome observations on the Log Fern Complex from the Rochester area, all from greenhouse rhizomes transplanted from the natural habitats. (For "pairs" some unrecognized multivalents are possible, and for "singles" some fragments, thus accounting for occasional deviations from multiples of 41.)

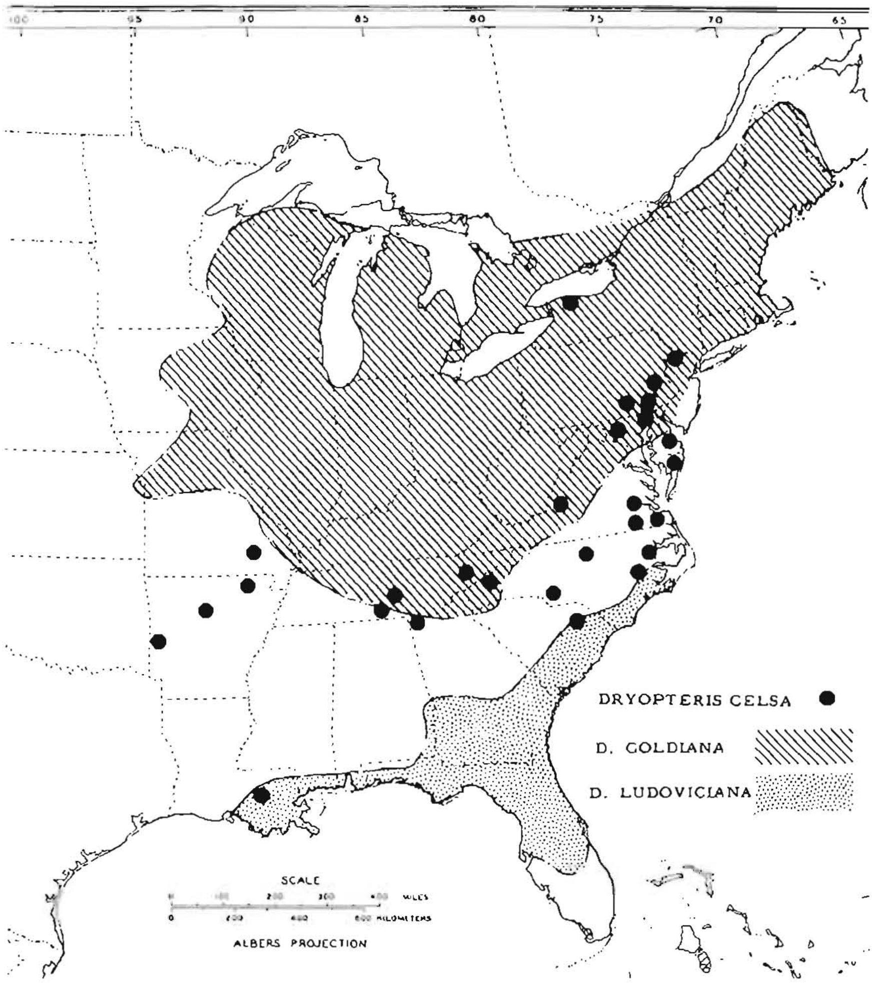

FIGURE 4: Map showing distribution of **Dryopteris celsa** (dots) and its nearest relatives (shaded areas).

at this place, of which there were four of species related to Log Fern. We believed when we were trying to identify these ferns at the time that they might represent three species—"**D. goldiana,**" "**D. cristata,**" and "**D. clintoniana.**" From each of the two large colonies of presumed "**D. goldiana**" (which were located in widely separated parts of the woods) we selected rhizomes for later study. We noticed that the plants were quite evergreen for the month of April and thus atypical of "**D. goldiana.**" We also dug up a rhizome sample from the colony of what we called "**D. cristata**" and one from the colony of "**D. clintoniana.**" As it turned out, not a single one of our field identifications was correct! Judging from our samples from the four colonies, *all* of the plants in "Cedar Swamp" are hybrids involving Log Fern.

Our "**D. goldiana**" proved to be **D. celsa** X **goldiana** (the chromosomes illustrated in Figure 2, 3, and the frond from the other colony in Figure 3, D). And both the putative "**D. cristata**" as well as the so-called "**D. clintoniana**" turned out to be the same—**D. celsa** X **cristata.** Thus, as judged by what we did find in "Cedar Swamp," even though we failed in our goal of finding true Log Fern, its "influence" is certainly present.

"Pocock Entrance, Bergen Swamp"

For our last excursion, Dr. and Mrs. Boardman graciously served as hosts and took us to the edge of the valuable natural preserve of Bergen Swamp (New York: Genesee Co., Bergen Twp., Pocock Entrance to Bergen Swamp, April 19, 1964). Here in the low, rich, damp woods we again found many fertile colonies of Log Ferns, these matching in size and vigor those of the "Riga Swamp". We made another large sample of living rhizomes from different colonies, over a dozen in all. Of these, 7 proved to be the normal Log Fern, **D. celsa**; 2 were **D. celsa** X **intermedia** (= **D.** X **separabilis**); 1 was **D. celsa** X **cristata**; 1 was putative **D. celsa** X **spinulosa**; and 1, judging from its morphology, was **D. cristata** X **marginalis** (= **D.** X **slossonae** Wherry); the last was our first record for this combination. All but one of these collections are new records for Genesee Co., N.Y., as far as we have been able to determine. Although we found no pure Crested Fern, **D. cristata** here, it is plausible that we overlooked it because of its deciduousness. It should also be noted that Dr. Boardman picked up a single specimen of **D.** X **bootii** (= **D. cristata** X **intermedia**) while we were exploring this swamp. **Dryopteris** X **boottii** is the best known of all North American woodfern hybrids and one of those most commonly grown in gardens. (We might mention, however, that **D.** X **boottii** is not nearly so showy as **D.** X **leedsii** and **D.** X **separabilis** which should certainly be tried as cultivated plants.)

CONCLUSIONS AND DISCUSSION

The data reported above lead to the following conclusions: The Log Fern, **Dryopteris celsa,** has been demonstrated to occur naturally in the vicinity of Rochester, New York, south of Lake Ontario. It is, in fact, rather abundant in certain localities. The map (Figure 4) shows the records of either typical **D. celsa** or its hybrids in comparison with the two most closely related diploid species, **D. goldiana** and the southern **D. ludoviciana** (Kunze) Small. The Rochester area collections considerably increase the known range of the Log Fern.

In this area the Log Fern evidently forms natural hybrids with other woodfern species very readily, and these crosses are either able to persist and multiply vegetatively to form large colonies or to spread by other means. In some localities "pure" populations made up entirely of Log Fern hybrids can be found, these involving such other woodfern species as **D. goldiana, D. intermedia, D. marginalis,** and **D. cristata.** From our experience, we have concluded that in at least some localities, one or both of the participating parents in a bispecific hybrid are no longer present and have disappeared.

The five new range extensions of taxa first reported here for the state of New York and the Great Lakes region are the following: **D. celsa, D. X leedsii** (= **D. celsa X marginalis**), **D. X separabilis** (= **D. celsa X intermedia**), **D. celsa X cristata,** and **D. celsa X goldiana.** In addition, certain nondescript hybrids were found which may represent **D. celsa X spinulosa.** For two of the hybrids, **D. celsa X cristata** and **D. celsa X goldiana,** in spite of their hybrid origin, we suggest that binomial taxonomic names and diagnoses should be proposed. (It should be mentioned that we now have very considerable evidence that both of these unnamed hybrids also occur commonly in northern New Jersey, as will be reported in the near future.)

Remarkably, our examination in detail of approximately fifty separate colonies in four different swamps failed to yield a single specimen of the plant traditionally identified as **Dryopteris clintoniana,** a common and widespread species throughout the northern and western Great Lakes region and recorded from many localities in New England. That fact that **D. clintoniana** was lacking from our collections suggests that materials heretofore identified as this species from New York state should be re-examined with the view that they may actually represent the Log Fern, **D. celsa,** to which **D. clintoniana** bears a resemblance.

Mention should also be made of the preliminary studies by the writers of the herbarium collections of woodferns in the Rochester Museum of Arts and Sciences (made through the courtesy of Dr. E. T. Boardman). These studies showed that the woodferns of this general area of New

York, as judged by the dried specimens, are in a state of taxonomic confusion, including many specimens of a critical nature. Thus a thorough revision is needed before we shall have an understanding of the occurrence and distribution of these plants.

Table 1 summarizes the chromosome data obtained in this investigation, as well as the identifications of our samples of living plants. It will be noted that some of the hybrid woodferns have little or no pairing of chromosomes, while others (specifically, **D. celsa** X **cristata** and **D. celsa** X **goldiana**), have a strong incidence of pairing, the number of pairs approaching the X number of 41. The significance of the pairing in **D. celsa** X **goldiana** has been already discussed by Stanley Walker (1962a), who concluded that **D. celsa** is a tetraploid species of hybrid origin between two diploid ancestors, **D. goldiana** and **D. ludoviciana**. One of the two sets of chromosomes in **D. celsa** is thus believed to be homologous to the single set of gametic chromosomes of **D. goldiana**, and the pairing in the hybrid is accordingly approximately 41 pairs and 41 singles. The significance of the similar pairing of **D. celsa** X **cristata** is not immediately evident and is being analyzed by Dr. Walker.

The results of this investigation emphasize the need for population studies in the field, and it is to be hoped that further and more extensive field studies of these plants will be carried out in this region by the local botanists, because it is evident that there is much yet which needs to be learned of their habitats, distribution, and variation.

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CHANGES IN THE LEVEL OF LAKE ONTARIO AS INFERRED FROM OFFSHORE SEDIMENTS AT BRADDOCK HEIGHTS, NEW YORK

R. G. SUTTON,[1] N. A. RUKAVINA,[1] and E. L. TOWLE[2]

INTRODUCTION

In June 1964, an exploratory survey of the Lake Ontario nearshore bottom near Braddock Heights, New York, was conducted by the Department of Geology at The University of Rochester (Figure 1). The survey was undertaken because of the plans by the Rochester Chamber of Commerce to construct an artificial shoal at that site. The shoal will modify the direction and magnitude of waves and bottom currents. These modifications in turn will alter the pattern of sediment distribution. The exploratory survey provides information on the character of the bottom for the shoal development program and acts as a control to determine the influence of the shoal on the sediment patterns.

Original plans of the Shoals Committee called for the emplacement of scrap automobile bodies in August 1964. In order to secure the needed data, we enlisted the cooperation of the U. S. Navy, whose ship, U.S.S. DeSoto County, was on tour in the Great Lakes. They provided a L.C.V.P. and U.D.T. divers during their visit to Rochester on June 18–20. The New York State Conservation Department provided a small boat, fathometer, and sample dredge. A small piston corer was obtained from the Lamont Geological Observatory. To all who contributed equipment and services we are truly indebted.

The results of this study have been reported in a paper at the 8th Conference on Great Lakes Research held at the University of Michigan in March, 1965, (Sutton et al, 1965). With permission of the Editorial Board, we summarize some of those results here.

SEDIMENT STUDIES

Very little is known about the character of Lake Ontario sediments. The only early study of these deposits is that by Kindle (1925). His samples were collected, for the most part, near the northern shore of the lake and were described in a qualitative fashion.

The first comprehensive, quantitative study was undertaken by Coch (1961). Beach samples from Webster to Port Ontario, New York were analyzed with regards to their mineralogy, mean size, sorting, skewness

1. Department of Geology, The University of Rochester.
2. Department of History, The University of Wisconsin at Milwaukee.

FIGURE 1. Previous photograph of study area.

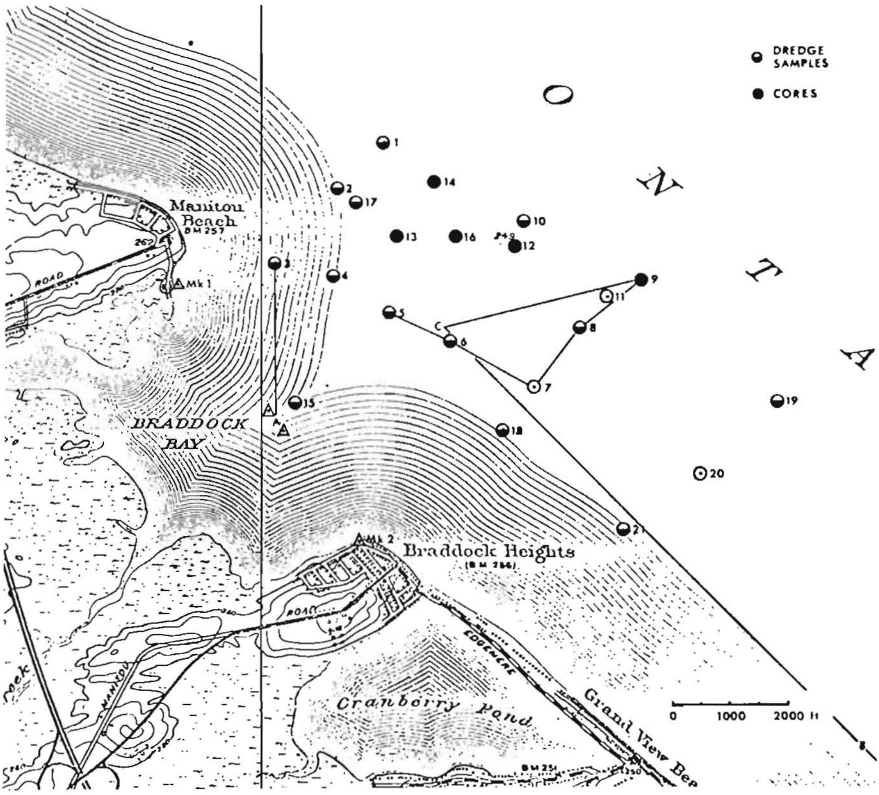

FIGURE 2. Sample sites and profile lines.

and kurtosis. Although the mineralogy was found to be uniform, the textural parameters were discovered to be dependent upon exposure to wave-action, at least in part. Coch concluded that the beach sands are derived from glacial deposits along the shore. Coch's study was confined to beach sands and did not extend west of Webster.

The southwestern shore of Lake Ontario is marked by several ponds and bays separated from the lake by spits and bay-mouth bars. A rise in lake level would produce a flooding of the low interdrumlin areas and result in an irregular shoreline. If the lake level remained fairly stable the lake currents and waves would tend to erode the points and erect spits and bars across the bays, straightening out the shoreline; the southwestern shoreline, in fact, shows this process nearing completion. The ponds would be gradually filled with sediment and marshes would appear along their margins. Ultimately the ponds would disappear and a balance would be reached.

Any change in lake level disrupts this evolutionary pattern and adjustments must occur. If the lake level drops the water table is lowered near the shoreline, the ponds drain and are cut by the streams that formerly deposited sediment in them. The bars and spits are easily eroded and the sand is moved toward the lake where it then forms a new beach on the older lake bottom.

If the water level rises, the beaches are submerged and new ones form inland. The new beach is formed of sand derived in part from the old submerged beach but much of it comes from the land sediments now exposed to wave and current action. As described above, the drumlins separating the ponds again form points in the lake and supply the sand for the beaches.

Currents in Lake Ontario are incompletely known but near the shoreline the prevailing current moves from west to east, undoubtedly the result of the prevailing westerlies. The currents should be strongest at the lake surface and diminish with depth. Convection currents undoubtedly play a role in movement of large masses of water but no data are available on these as yet. It does seem logical to assume that wave and current action diminish with increasing depth, a common pattern in lakes. This means, of course, that the size of sediment grains moved by these forces would also decrease with increasing depth. The grain size then should decrease with increasing distance from shore and a corresponding increase in depth.

Thus, if the lake level rises, any point on the lake bottom should have finer-grained sediments deposited on top of coarser-grained sediments. If the lake level falls the patern should be reversed. It is unlikely that changes of a few feet in lake level would result in significant changes of sediment size at lake depths of 30 feet. Similarly, changes of a short duration (5–20 years) might not be noted due to the slow rate of sediment accumulation. Changes of a greater magnitude operating over a longer period of time should be preserved.

The erection of the artificial shoal near Braddock Heights offers the unique opportunity to observe the effect of a change in both depth and current pattern. The preliminary survey was necessary to establish a control for comparison with data that can be obtained after the shoal is erected. The depth, grain size, sorting, skewness and kurtosis, had to be determined. From cores of the sediment obtained some interpretation of earlier depth and current changes can be made.

The Braddock Heights area offered many advantages for the study. Braddock Bay represents only one phase in the evolution of the entire shoreline. Results in this area would be applicable to the entire shoreline west of Rochester. Braddock Heights is situated on one of the partially eroded drumlins that separates Cranberry Pond to the southeast from Braddock Bay to the northwest. (Figure 1). The survey area lies offshore from the bay and extends from the bay mouth to a depth of 50 feet, a distance of 1.5 miles.

A total of 18 sediment samples were obtained by means of a dredge. Depth was determined by one of three methods: fathometer, depth line on the dredge, and diver's depth gauges. Fathometer profiles were obtained during the first part of the operation but equipment failure made it necessary to rely upon other methods at most of the sampling sites. Sample locations were determined by sextant readings and compass bearings on two specially constructed shoreline markers. (Figure 2).

During the few days that the boats and equipment were available to us, most of our efforts were directed to the construction and rigging of a piston corer which was tested in different sediments at varying depths of water. The piston corer was found to be unsatisfactory in shallow water for coarse-grained sediments. Only one complete core was obtained in the usual fashion, after several unsuccessful drops. Four other cores were then obtained by having divers push short lengths of acetate core-barrel liner into the sediment and cap them. Efforts to obtain a camera to photograph the lake bottom also proved unsuccessful. However the divers were instructed to make critical observations and measurements so that some interesting and important data were obtained.

DESCRIPTION OF THE AREA

The study area was found to form a smooth, sandy plain that slopes gently to the northeast (Figures 3 and 4). Some notable exceptions were discovered however. For example, a fathometer profile was run parallel to Grand View Beach, opposite Cranberry Pond. The water depth was

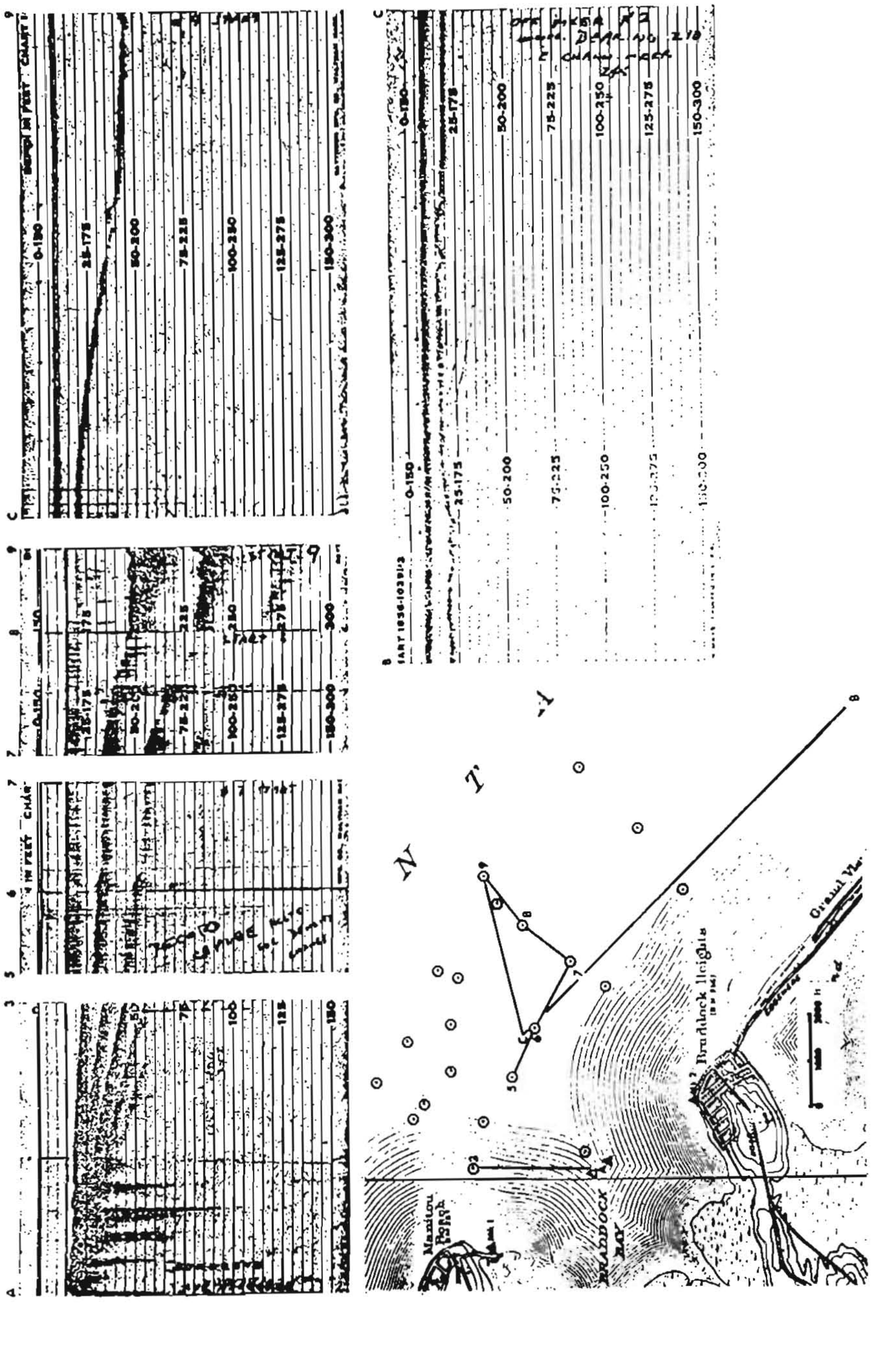

FIGURE 3. Fathometer charts showing some of the depth profiles.

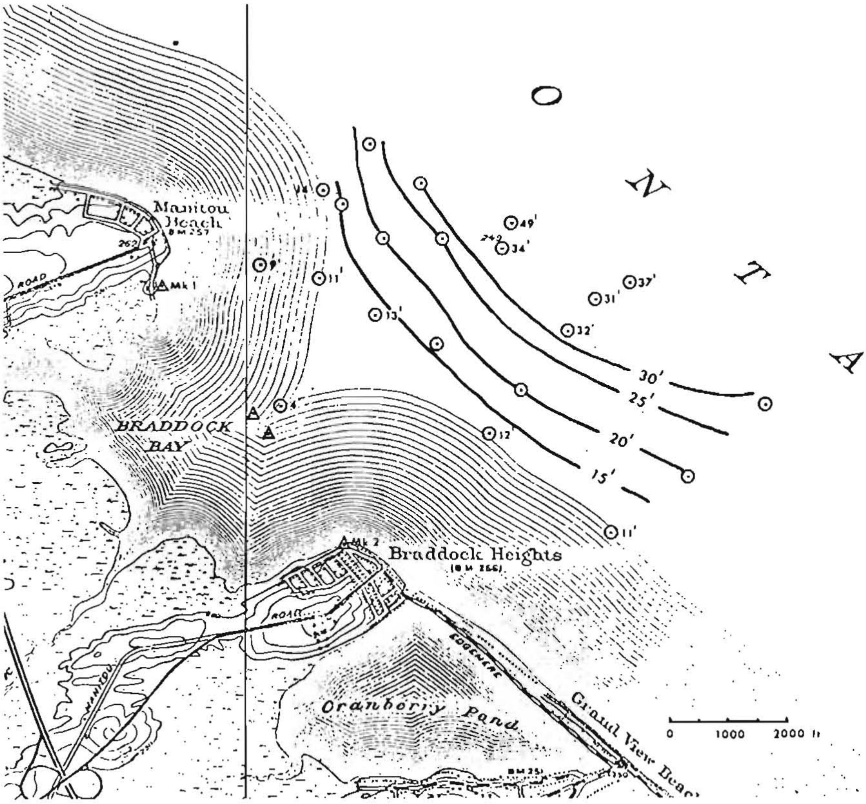

FIGURE 4. Subaqueous topography.

rather uniform except for two 5-foot depressions. No such features have ever been reported in this area or elsewhere in the Great Lakes. These depressions may mark the position of small trenches formed at a time when Cranberry Pond maintained a free outlet to the Lake. Another interesting discovery was made along Profile C–9 at a depth of 25 feet. At that point the sand plain appears to terminate and the bottom slope increases markedly. This observation became more significant when a similar pattern was found at a depth of 30 feet on Profile 7–8–9.

At locality 11, the dredge failed to bring up a sand sample. Divers reported a large accumulation of boulders, some 4 feet in diameter. Cobbles and boulders were also found at depths of 30–40 feet in an area northeast of Manitou Beach. Their presence is also inferred from failures to retrieve dredge samples at localities 7 and 20 (Figure 2). The size and shape of the boulder areas could not be determined because our fathometer equipment was not operating when they were discovered. They do offer excellent sites for anchoring parts of the artificial shoal. Their origin is discussed below.

As expected, current ripples were noted in the sandy areas by the divers. From the compass orientation of their crests and the slope of sand on either side of the crest it is possible to determine the direction of the current responsible for their formation and thus the direction of sediment transport. The orientation measurements obtained were few but those obtained confirm the presence of a southeasterly current in the area. This confirms the direction previously reported by Harrington (1895).

Large ripples, or megaripples, occur in a narrow zone adjacent to the shore. They measure several feet between crests rather than several inches as in the case of the current ripples. The ripples were recorded in the fathometer profile A–3 (Figure 3) and are discernible northeast of Cranberry Pond (Figures 1 and 4).

RESULTS OF LABORATORY ANALYSES

The techniques used in the analysis of the sediment samples and the data obtained have been reported in a paper given at the 8th Conference on Great Lakes Research. For these details, the reader is referred to the Proceedings of that meeting. The significant results are summarized below.

Two types of sediments could be identified. The shapes of the cumulative curves were different and the mean size, sorting, skewness, and kurtosis for the two types were compared by student's T and F tests and found to be significantly different. One type was collected from depths less than 25 feet, the other type at greater depths. However, instead of finding the coarser sand near the shore, just the reverse was discovered.

Size values for the nearshore sand were remarkably uniform while those for the deeper sands were highly variable. Higher kurtosis, a more negative skewness, and lower percentage of fines also characterize the shallow-water sands. The boundary between the two sediment types appears to coincide with the line marking the abrupt change in slope as described above. Clearly, any interpretation of the lake history must explain the differences in the sands and their relative depths.

The cores display a heterogeneity as to grain size and sedimentary structure. Sediment samples were removed from the cores and treated in the same manner as the dredge samples. Samples from the cores were found to have the same statistical parameters as those from dredge samples at the same depths. The cores showed distinct stratification and cross-stratification in the sandy portions. Gastropod and pelecypod shells and shell fragments were recovered from all of the cores.

Of considerable interest is the presence of a zone of plant material found in 3 cores obtained in water depths greater than 25 feet. No organic layer was in the shallow-water core. This zone is approximately 10 cm. thick and its top occurs at an average depth of 20 cms. in the cores.

Gastropods and pelecypods shells and fragments were observed in many of the dredge samples as well as in all of the cores. They were notably absent in the organic layers.

INTERPRETATION OF THE RESULTS

Some general conclusions and interpretations may be drawn from the field and laboratory data gathered to date. Sediment source, mechanisms of sediment distribution, origins of the subaqueous topography, and evolution of the shore area are considered here. Because this study is a preliminary one, additional data must be gathered before these results can be confirmed. Instead, these results should be considered as working hypotheses that form the basis of future studies.

The sands that lie beyond the beach but in depths less than 25 feet are considered to be a product of wave and current activity now operating in that zone. They are delineated by better sorting, lower percentage of fines, and a higher kurtosis value. Normally, the sands in water with depths greater than 25 feet are subjected to wave and current activity too weak to modify the sedimentary parameters. Wave base may be at this depth except during times of storm activity. Currents may also decline in velocity at these depths. These two factors are believed to be responsible for the differences in the two types of sands but they cannot explain the higher percentage of coarse material found in the deeper sands.

During the summer months, the prevailing northwesterly currents supply most, if not all, of the sand to the nearshore area. During the winter months, a period of general storm activity, wave and current activity would be considerably greater and larger grains would be transported. This would result in larger volumes of sediment, both sands and fines, being moved away from the shore and deposited at greater depths. With the return of the summer months, the gentle northwesterly currents improve the sorting of the nearshore sands. The currents are capable of transporting only fine sand that dilutes the coarse sand. The fines are winnowed out and deposited in deeper water. In this way we can account for the improved sorting of the shallow-water sands and the lower percentage of coarse material. To test this hypothesis the current pattern should be studied during the summer and winter. If the hypothesis is correct we would expect an abrupt shifting in the pattern from a southeasterly direction during the summer to a northerly or northeasterly direction during the winter.

The two boulder areas opposite Braddock Heights and Manitou Beach are of considerable interest. They are interpreted as sites of drumlins that were subsequently eroded. The boulders represent the remnants of glacial drift that has been nearly all removed by wave and current action. If this is true, the drumlins would have flanked a bay that is presently covered by the lake to a depth of 25 feet. Once the drumlins were eroded away, the shoreline would have moved to the southwest where it would have been protected by the drumlins at Braddock Heights and Manitou Beach. The zone of organic material in the cores is cited as evidence that a bay formerly existed in that area. Just above the organic zone are coarse sands (no fines) that are similar to present-day beach sands. The coarse sands grade upward to the deep-water sands described above. The sequence is interpreted as evidence of deepening water and the drowning of an earlier bay. A landward migration of the beach unaccompanied by a rise in the water level would have resulted in the destruction of the organic zone. From the data at hand a rise of 25 to 30 feet would explain the observations and data gathered to date.

It may be possible to determine the age of the earlier lake level by dating some of the shells found just above and just below the organic zone.

SIGNIFICANCE OF RESULTS

Current and waves play a major role in controlling the type of sediment that exists in the lake near Manitou Beach. Construction of an artificial shoal should, within a few years, change the sediments southwest of the shoal. The changes should not cause any deleterious effects, but an accumulation or shallowing might take place, possibly after several decades. The boulder areas offer good sites for anchoring the artificial shoal. Because we have no knowledge of the accumulation rate, we cannot predict the rate of accumulation near the artificial shoal. Dr. Wallace

Broecker, at Columbia University has agreed to determine the age of the fossil shells by radio-carbon dating. When this information is available, it may be possible to predict the accumulation rate for the area, particularly near the shoal site.

The changing character of the sands with depth can be used to interpret the history of the lake itself. If bay sediments were preserved beneath the lake, former bays may have existed before that and their organic sediments may still be preserved at depths below the zone cored in 1964. The boulder areas could be traced beneath the lake sediments by existing geophysical techniques. From such data it would be possible to determine the configuration of the area before it was covered by the lake. At the present time we know virtually nothing about the history of Lake Ontario, a history that could tell us much about post-glacial events in western New York and portend the changes in the centuries to come.

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EXPERIENCES IN CONDUCTING A MUSHROOM FIELD COURSE

by

LEO J. TANGHE, Ph.D.

Fellow of the Rochester Academy of Science

Fellow of the Rochester Museum

From time immemorial hobbies have been avenues of social and intellectual stimulation for many people. Modern technology with its short work hours, extended vacations, and early retirement has led to the development of hobbies of all kinds. Among those listed in a brochure of the Rochester Museum Hobby Council a considerable number are in the natural sciences.

Field trips play an important part in the development of these hobbies for adults. They engender a great deal of satisfaction, probably because they extend former activities experienced as children and students; hikes to parks and woods linger long in the memories of childhood. A background of field trips has often been the outstanding part of high school and college courses in the natural sciences.

Mushrooms and other fungi are just as interesting and challenging as more firmly established subjects of study, such as minerals, birds, and flowers. Under the sponsorship of the Rochester Museum Association during the past three years, I have had the opportunity of leading field courses in the identification of mushrooms. Some of my experiences and recommendations are recorded in this article in the hope that they may encourage and guide other potential leaders.

ORGANIZATION

Sponsor and Publicity

The organization of a field trip course requires a sponsor well established in the community so that prospective applicants will know that the course will be conducted in a responsible manner. Schools, museums, YMCA's, and similar organizations established in adult education have this respect and confidence of the community.

The sponsoring organization has means of publicity to reach prospective applicants by its regular publication, or by special brochure or letter. Additional publicity may be furthered by bulletin boards, city daily newspapers, and suburban weeklies.

Field Course Leader

The leader must have a reasonable, but not necessarily exhaustive knowledge of his subject. More important is his ability to communicate his knowledge and to instill in others enthusiasm for his subject. He must respect the willingness of members of the group to learn more than they know at the beginning of the course.

Participants' Motives

The motives for mushroom study were reviewed in my recent article (Tanghe, 1964) announcing the Mushroom Spotters Field Course for 1964. While mushrooms for food may rank high among the interests of the participants, this aspect received only minor emphasis during the courses.

Schedule of Dates and Places

The abundance of mushrooms varies greatly from year to year and during the growing season of a single year. Each mushroom has its own pattern of seasonal abundance; beyond that the greatest single factor favoring mushroom growth is an abundance of rainfall. Even though late July and most of August are often rather dry in this area, some field trips should be scheduled during this interval. The field trip schedules were set up in advance so that prospective participants could plan summer vacations and travel. Even so, in our experience nearly every participant missed one or more field trips because of conflict with other activities.

Perhaps the dominating factor in a field trip schedule is the vacation and travel plans of the leader. This can severely limit the time available for field trips.

At least one indoor meeting is desirable to present some basic material. A schedule of two indoor meetings and six or more field trips was announced before the beginning of the courses. The first indoor meeting was held at the beginning of the course and the second near the middle. These were evening meetings held at the Rochester Museum of Arts and Sciences. Most field trips were held on Saturday afternoons from late July to early October.

Indoor Meetings

The first meeting was a broad review to establish the concepts of the terms: fungus, higher fungus, mushroom, toadstool (poisonous mushroom), and agaric (mushroom with gills). Some of the common terms in mushroom vocabulary—pileus, lamella, annulus, mycelium, etc.—were described. Spore prints were shown and the classification of agarics according to spore color was presented. Further classification was presented according to the presence or absence of annulus and volva. These points were demonstrated with freshly collected material as far as possible.

Also at the first meeting various mushroom books were displayed, mushroom growth was described, some comments were made on mushroom poisoning, and several typewritten sheets of mushroom material were handed out.

During the third year of the course the second meeting centered around the microscope as an aid in identification. Demonstrations were set up to show spores on basidia and in asci, representative of the two major methods of spore arrangement. Probably not many participants care to pursue mushroom study this far, but I think it is desirable to present this material since it is the basis of current mushroom study and research. The importance of these microscopic characteristics was shown by displaying modern monographs dealing with only a single genus (Hesler and Smith 1963) or with a limited group (Overholts 1953) of mushrooms.

Problems of mushroom nomenclature and classification were considered briefly at the second indoor meeting. These problems were illustrated by showing the complete synonomy of names which some authors present for each species they describe. For example, **Hygrophoros miniatus miniatus** has been described in the mushroom literature under nine other names (Hesler and Smith, 1963, page 156). More often the problem is one of coordinating "old names" and "new names." For example, the "chicken mushroom" is described in the older books under the name **Polyporus sulphureus** (McIlvaine, 1912, page 485), but in the newer books (Smith, 1963, page 62) as **Laetiporus sulphureus.**

At one of the indoor meetings some of the mushroom models at the Museum were brought out for display.

FIELD TRIPS

Field trips are time-consuming, and after the middle of August there is hardly enough light for a satisfying field trip in the evening after work. Devoting half of a Saturday or Sunday in order to have ample time for the field trip proved a better plan. A schedule I have found quite satisfactory is to gather at the announced destination at 12:30 P. M. for lunch (optional) and 1:30 P. M. for the hike. This gave some latitude in arrival time and allowed the participants to get acquainted during lunch. Some people brought specimens to display at this time.

During the three years of mushroom field courses, trips were made to Durand Eastman, Mendon Ponds, Powder Mill and Letchworth Parks, Bergen Swamp, Zurich Bog (Sodus, N. Y.), Bentleys' woods, (Fishers, N. Y.), and to the home of Mr. William Smith, Lyndonville, N. Y.

Distances up to 50 miles did not seem to present any problem in transportation.

There is usually no objection to collecting specimens of fleshy fungi from these places, although the conservators of Bergen Swamp and Zurich Bog are committed to the principle of not removing any plant material from these locations. Perennial growths should not be removed except when there is an abundant growth of the species or when the material will be used for scientific study. The same principle should apply, but with lesser stringency, to annual growths of the slowly decaying fungi.

On field trips some participants preferred to keep close to the leader to see and hear as much as possible, while others preferred to break away from the group to cover more territory and to find something different. A good field trip should allow a happy balance between these two behaviors. The leader should go slowly and look carefully even after others have gone ahead. It is important to observe mushrooms in their natural habitat and to point out in fresh specimens such characteristics as the annulus, volva, milk (of **Lactarius**), and spore deposit (when observable). Field trips present an ideal time to point out variability within a species. Photographs in books usually show mushrooms in prime condition. Very young and very old specimens may look quite different. The ideal way to observe mushroom growth is to return to the same area to see the same plants throughout their growth, but this was not possible under the plan of these courses. However, young and old mushrooms are often found growing under conditions that indicate they are obviously of the same species, and the field trip leader should call attention to such displays.

Collecting specimens were displayed not only as they were found to persons nearby, but also at intervals during the field trip to those who had been away from the group temporarily, and also at the end of the trip to the entire group. Small plastic bags were found to be suitable for protecting the specimens, since they could be displayed in them during the trip without unwrapping. When there is no need to display specimens before taking them home for study, small containers made by folding and twisting sheets of wax paper are preferable because they are sturdier. In any case moist soil, leaves or humus should be included with certain specimens to prevent them from drying out too rapidly.

During the trip the leader should name the various species and give any other interesting information he may have about them. The participants should keep at least some notes during the field trip. These should include some brief field marks along with the names of those species which are of special interest.

A well-planned field trip should allow enough time to review and display specimens at the end of the trip. At this time everyone should have the opportunity to ask about specimens in his own collection and sometimes to exchange specimens with others.

On two occasions when field trips were combined with the annual picnic of the Rochester Academy of Science the mushrooms were displayed on tables and supplied with name tags. These exhibits aroused considerable interest since many people were unaware of the vast variety of fungi growing in the area.

The field trips of the mushroom courses of the past three years yielded 25 to 60 species per trip. Because the years 1963 and 1964 were dry during the mushroom season, some of the trips were relatively unproductive. Best variety was found in Bentleys' woods and in the woods near Lyndonville, N. Y. Specimens included mostly agarics, boletes, and polypores, but also a few stinkhorns, hydnums, coral mushrooms, and cup fungi. It is not the aim of this report to list the species found, but a few of the more unusual ones are worthy of mention.

At Lyndonville we found the **Hydnum auriscalpium** growing on decaying pine cones—the only known habitat for this species; also a fairy ring of 69 specimens of **Clitocybe candida** growing in a ring about 70 feet in diameter. At Powder Mill Park we found the slippery **Leotia lubrica** and in 1962 an abundant growth of **Craterellus cornucopoides**, also called "horn of plenty." Bentleys' woods is a regular habitat for **Boletinus pictus, Helvella crispa,** and **Craterellus cantharellus.** The cranberry bog at Mendon Ponds had the beautiful red Hygrophorus with the long stem, **Hygrophorus miniatus longipes,** growing deep in the sphagnum.

STUDY ACTIVITIES

After the Field Trip

My most urgent task immediately after the field trip was to compile a list of mushrooms observed. This list was mailed to members of the class so that everyone had an authoritative list against which he could check his own notes. Brief comments were made on some of the species to help associate the mushroom with the name.

A second activity was to make notes to establish identification of new species whenever possible. This was often a seemingly endless process, sometimes continuing far into the night.

Some species were photographed or tested for edibility.

Books and Hand-out Material

At the first meeting the participants were urged to buy a book if they did not already have one. General books, such as those by Groves (1962), Smith (1963) or Thomas (1948) were recommended. Display of monographs, such as those by Seaver (1961) on the cup fungi and by Hesler and Smith (1963) on Hygrophorus, showed the quality of current mushroom study. Since many books have only a few, if any, color plates or photographs, Kleijn's (1962) book with its magnificent color photographs was passed around.

Also at the first meeting I handed out some typewritten sheets of mushroom data I have assembled from various sources. The first ten sheets were a list of some mushrooms growing in the Rochester area. This list, drawn up from my own experience, represents only a small fraction of the mushrooms in this area. The mushrooms were arranged by groups, starting with those having gills and white spores. Within each group they were arranged alphabetically by genera, and within the genera, by species.

I have searched each of 13 books for descriptions and photographs of these mushrooms and have tabulated the results so that, in a single line of type for each mushroom, the treatment accorded by each author is indicated by a single letter. Thus for **Amanita brunnescens**, the first mushroom on the list, the tabulation shows that books by Groves (1962), McIlvaine (1912) and Thomas (1948) have color photographs or drawings, as indicated by "C". Smith (1949) has a color stereo photograph, "S". Atkinson (1901), Hesler (1960), Pomerleau (1951), and Smith (1963) have black and white photographs, "P". Christensen (1955), Krieger (1936), and Kauffman (1918) have written descriptions, "D". Books by Lange (1963), Overholts (1953), and Ramsbottom (1953) make no mention of this mushroom. Similar information is tabulated for every mushroom on the list. In appropriate places "L" indicates a line drawing and "M" indicates mention or comment, but without formal description. In a final column "W" indicates that the Rochester Museum of Arts and Sciences has a wax or plastic model of the mushroom. This list is a big help for class members in finding information about the mushrooms reported on the field trips.

Other hand-outs were single sheets devoted to a general classification of fungi; classification of gilled mushrooms; classification of white-spored mushrooms with gills, but without annulus or volva; and notes necessary for the description of a mushroom.

Problems

The prime problem in a mushroom field course is simply to identify the mushrooms. This may seem to be an obvious statement, but it would not be a major problem with some other subjects. For example, a competent field leader in bird identification would not often find more than one species in a day that he could not identify under favorable conditions of observation. With the fungi, however, the difficulty is due in part to the large variety of fungal flora and also to the lack of comprehensive field identification manuals.

A problem in the contrary direction is that of finding sufficient variety of mushrooms to make an interesting field trip. When dates and places are scheduled in advance, it is impossible to take advantage of day to day variations in the weather. The only answer is to go to usually productive areas and to be content with what nature provides.

The lack of suitable books and manuals for field identification is not likely to be remedied in the near future since many mushrooms are still unnamed and many more are not adequately described. "Keys" for the identification of mushrooms are helpful but they do not by any means solve all identification problems. Keys are valid only for the species in the key; when the species is not in the key, it might be forced to fit the key and thus be misidentified. Perhaps the biggest problem in the use of keys is to know the author's intent at each of the many pairs of alternate choices. It is helpful to practice on a known species in order to observe what choices the author made in placing the species where it appears in the key. Keys for a given genus vary widely from author to author, depending on the number of species included and on the sequence in which the characterizing differences are used.

Beginners in mycology are sometimes frustrated by the confusion of names in the mushroom literature. The older nomenclature was based only on macroscopic characteristics, whereas the newer draws heavily on microscopic examination and staining techniques. The latter characteristics are often more constant, providing fundamentally sounder system of nomenclature and classification. The transition period we are now in is difficult because both old and new names are in current use. Some of the better older books (Atkinson (1901), Hard (1908), and Kauffman (1918)), written 50 years or more ago, have recently been reprinted, thus perpetuating the older nomenclature.

Rewards

I have found the mushroom courses of the past three years a very rewarding experience. I have made acquaintances with local people of similar interests and with some of the leading mushroom authorities of the country. My knowledge of mushrooms has increased as much during this interval as during the previous 15 or 20 years.

I am sure that the participants in these courses now have a keener awareness of the variety of mushrooms in our fields and woods and that they have learned to identify at least some of the commoner species.

ACKNOWLEDGMENTS

I wish to thank Mr. W. Stephen Thomas, Director of the Rochester Museum of Arts and Sciences, for his interest in promoting these field courses and his secretary, Miss Wilma Shili, for preparing copies of the hand-out sheets and reports of the field trips.

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AN ABSTRACT OF THE SCIENTIFIC METHOD AS PRESENTED IN SCIENCE TEXTBOOKS AND AS DESCRIBED BY EMINENT SCIENTISTS*

by

ERNEST D. RIGGSBY

Associate Professor of Science

at

Troy State College
Troy, Alabama

INTRODUCTION

For some time the feeling has existed that textbook authors, who are not at the frontier of scientific investigation, may have presented a distorted concept of the scientific method. If such a distorted interpretation has been presented, a critical, comparative analysis of randomly selected textbooks and appropriately selected writings of eminent scientists should reveal significant differences.

The study being reported deals with the degree of correspondence between two such samples, as described above, and a reference group composed of accepted, authoritative writings on the subject (by such authors as: Campbell, Cohen, Hansen, Hull, Mintague, Nagel, and Wolf).

METHOD

1. The method of the study was descriptive-analytical. Classical sources were investigated to develop a working description of the components (*elements*) of scientific method.

2. A stratified random sample of school science textbooks, in print in 1961, was selected and subcategorized into these groups: grades seven through nine; grades ten through twelve; and grades thirteen and fourteen. These textbooks were used to identify the authors' viewpoints and definitions of scientific method.

3. A categorized random sample of eminent scientists was chosen and the description(s) of scientific method were isolated from each of their writings. Correspondence (personal letters) from the scientists was used to validate the scientists' current position regarding

* Complete study available from University Microfilms, Inc., Ann Arbor, Michigan.

the interpretation and description of scientific methodology. The differences and similarities between the two sets of descriptions were identified. All of the scientists in the sample are living members of The National Academy of Sciences of the United States of America; six of them are Nobel Prize winners.

The categories of scientists selected were: astronomers, biological scientists, chemists, geologists, and physicists. Forty-one scientists were involved in the study. Thirty-nine of them contributed to the study, through personal letters, published writings, personal and telephone interviews, and both structured and unstructured responses to interrogation by the investigator.

Thirty-four months were required for the study.

4. A comparative analysis was effected.

ASSUMPTIONS

The findings were limited to these assumptions: (1) the samples were adequate to be representative of the range of interpretations; (2) critical analysis was an appropriate method for identifying areas of difference and similarity in presentation; and (3) definitions adequate for analysis and comparison could be isolated from the groups under study.

FINDINGS

1. These five characteristics were identified as elements of scientific method in the reference (classical) sources: *causation, classification, consensus, experimentation,* and *observation.*

2. Definitions of the five reference elements were substantially agreed upon in the reference literature.

3. With two exceptions, the "steps-to-follow" procedure (after Pearson), although variously presented, was described in textbooks.

4. Junior high school textbooks most emphasized the attitudes of scientists, rather than descriptions of scientific method *per se.*

5. Specialized books in the senior high school category contained diverse presentations, representing mainly the "steps" approach to scientific discovery. Perhaps, on the order of one-fourth of the textbooks used biography or the description of classical experiments as illustrative material.

6. The textbooks substantially agreed, with respect to definitions of *experimentation* and *observation.* Inferred agreement was contained in the textbooks concerning *consensus* and *classification. Classification* was

presented in the sense of the taxonomy of scientific realia, not in the sense of the ordering of ideation and knowledge.

7. The scientists' descriptions were characterized by diversity. More interestingly, the biological scientists, the astronomers, the geologists, and the physical scientists were more alike, than divergent, with respect to within-group interpretations.

8. Scientists' presentations varied from a disclaiming of the existence of a scientific method, to outlining in detail, factors, not steps, in scientific methodology. There was appreciable agreement among scientists, that discovery in science is a personal effort, but the presentation of one's discovery follows definite rules of procedure.

9. Agreement among scientists was substantially strong that *experimentation* and *observation* are important aspects of scientific method.

10. *Classification,* interpreted as the ordering of knowledge, was not specifically listed, but was inferentially suggested by the scientists.

11. Scientists, to the extent of approximately one-half of the sample, emphasized the personal nature of scientific discovery and the public nature of its organization. Textbook writers, by contrast, were not so precise.

12. Neither scientists nor philosopher-scientists gave serious consideration to the importance of *consensus.* It may be that *consensus* is the more proper concern of those who write encyclopedias and treatises.

13. Textbook writers worked for simple causes and effects; the philosopher-scientists and scientists attempted to identify and to differentiate between multiple causes and concomitance. Causation was a strong point of inferred variation between scientists and textbook authors. The life scientists agreed that the problem of citing causes was difficult. Certain astronomers and physical scientists expressed concern with empirically constant relationships, rather than with causation.

14. Textbook authors viewed the outcomes of scientific investigation (experimentation or application of the scientific method) as highly certain and usually precise; the scientists sample, by contrast, described scientific discovery as a flexible, dynamic, and not always certain procedure.

15. Scientists recognized that much experimentation is trial-and-success; textbooks generally gave this topic only very brief treatment.

16. The rigidity of definitions in textbooks contrasted strongly with the descriptions of scientists. The static nature of methodology found in textbook presentations is opposed to the dynamic, evolutionary nature of scientific method as described by scientists.

17. Uniformity of presentation of scientific method was a prime characteristic of textbook writings; diversity of description was abundant in the scientists' writings. Textbooks typically centered around the "steps-to-follow"—those steps being, of course, (a) define a problem, (b) form a hypothesis, (c) test the hypothesis, (d) gather data, and (e) form a conclusion.

18. Textbooks presented more rigidly structured approaches to scientific methodology while scientists argued for flexibility, intuition, serendipity, probability, and luck. However, the writings of the scientists did not communicate the idea that scientific investigation is a haphazardly arranged enterprise, operated by undisciplined researchers. The scientists agreed that the rational processes and ideational organization of the researcher may not be revealed by his experimental *modus operandi.*

UNSOLVED PROBLEMS

Certain questions or problems were raised by the investigation; they suggested a need for further study. Among these problems were:

1. Is scientific method an art of such dimension that it cannot be adequately and simply verbalized for inclusion in school science textbooks?

2. Is the *"logic of the discovered"*—the laws of science—instrumental in forming the *logic of discovery*—scientific method?

3. Can a science curriculum be designed for teaching the *process* of scientific discovery?

If the production of science researchers and the early identification and "training" of scientific talent remains one of the important functions of the schools, it appears reasonable to pursue further investigations of these questions in an effort to determine what is "correct" and "teachable" concerning scientific method.

CITATIONS IN THE ROCHESTER ACADEMY OF SCIENCE

1964

ALBERT W. BUSSEWITZ

Honorary Member

Our candidate is the Director of the Stony Brook Nature Center, from which office he can advance the trident purpose of conservation, research, and education. This is carried out on the Bristol-Blake Reservation in Norfolk, where the Massachusetts Audubon Society has accepted the invitation to interpret to visitors this 200-acre outdoor museum of ponds, woods, and meadows. Thereby a burgeoning cooperation between a public agency and a private organization has begun. This is a notable step in the preservation of our heritage of natural resources against needless destruction as a result of the inevitable expansion of our cultural resources.

He comes to this post with a background in harmony with his responsibility. Raised in the dairylands of Wisconsin, he knows and likes outdoor life. A degree from Northwestern University and graduate work in natural science at the University of Wisconsin formally taught him about the life in the outdoors. While working in the Precision Optics Division of Bausch and Lomb, Incorporated during the war years of the 1940's, he conducted nature classes and field trips for the Rochester Museum of Arts and Sciences. He was an officer of the Genesee Ornithological Society and of the Burroughs-Audubon Nature Club. Many members of our Academy can conjure up a mental picture of him striding out from Pittsford for a nature hike with his family, in any weather and with the lunch and the youngest child stowed together in his pack-basket.

He has directed other sanctuaries in Massachusetts. He has been energetic in conducting day camping and in teaching conservation for the schools there. And he is active in many societies having compatible interests.

For using science to enable us to save and to enjoy what we have, we are cordially tendering him the title of Honorary Member of the Rochester Academy of Science.

FRED C. AMOS

Fellow

Our candidate whetted his interest in astronomy and geology when in high school in Wheeling. This was further sharpened in working for his bachelor's degree in geology from the University of Chicago. Some graduate work there plus field experience in the Mid-West gave him three years of varied experience. In 1955 he joined the Geology Division of Ward's Natural Science Establishment Incorporated as Head of the Paleontology Department.

Now, as Director of Research and Development, his special flair for presenting information clearly enables him to create ingenious visual aids to education. He is a capable artist and a member of the Rochester Audio-Visual Association.

He carries his abilities into his leisure activities. He has often spoken to school, scout, and church groups. His lectures have intrigued many with the story of the complex, weathered, upheaved, and sedimented crust of our globe and the hoards of specimens embedded in the rocks. He has extended these presentations to the lecture program of the Rochester Museum of Arts and Sciences and to educational television sessions.

He is past Chairman of the Mineral Section of the Academy and currently is on the Council.

For effectively combining Earth science, art, and teaching ability, we proudly accept him as a Fellow.

Harold Carpenter Hodge

Fellow

The benefits of science are many, but there are also many dangers. Our candidate applies scientific skills to determine both the safe and the hazardous properties of the substances science provides. He is now chairman of the Department of Pharmacology at the University of Rochester. His early education in Chicago was followed by work for a degree, Doctor of Philosophy at the University of Iowa in 1930. A few years teaching, assistantship at the University of Rochester, and a professorship in pharmacology and toxicology preceded his present chair. Recent events have added the discipline of radiation biology to the facets of his work.

He has served as consultant or member on numerous councils and committees in his field and belongs to eleven societies. He has been president of two: the International Association of Dental Research and the Society of Toxicology. Among his particular scientific interests are studying the physical and chemical properties of the constituents of teeth and bone and the toxic potentialities of everyday articles and substances. A special interest is methods of medical and scientific education and he recently completed a world tour visiting medical schools.

With Marion N. Gleason and Robert E. Gosselin he compiled the monumental work entitled Clinical Toxicology of Commercial Products. This book influenced, at least in part, the Congress of the United States and the Food and Drug Administration to pass the Hazardous Household Substances Act, the primary aim of which is to prevent poisoning of children.

He is associated with the Library of our Academy and has served for several years on the Editorial Board.

For his accomplishments and his intensity of purpose, we are proud to grant him our honor of Fellow.

Gerhard W. Leubner

Fellow

Having his formal training for a vocation in organic chemistry, biochemistry, and physiology, it is not surprising that our candidate should gravitate toward natural science as an avocation. The former was obtained first at Union College and then, upon completing his doctorate in 1948 at the University of Illinois. The latter finds outlet in our Academy through active membership in the Genesee Ornithological Society.

He is a Research Associate for the Eastman Kodak Company. He has investigated the synthesis of photographic chemicals and of photosensitive polymers. Presently his work is in patent liaison for the Chemistry Division.

His penchant for research extends into his ornithological interest. For the Society he has served on the Statistical Committee and he is compiler and custodian of the Rochester Christmas Bird Count reports. Banding projects receive much of his time and attention.

He has served in other ways: with program, conservation, and national meeting enterprises of the Society. The birds, too, have reason to be grateful, for he handles about seven tons of seed a year for club members. Talks on ornithology to scout and garden groups round out his nature activities.

For carrying out the letter and spirit of the Academy's purpose of furthering knowledge and disseminating information gained from that knowledge, we extend to him our honor of Fellow.

Mildred Stauffer

Fellow

Science can help us save what we have as well as give us new things. Our candidate is an ardent conservationist, having been three times a conservation chairman in ten years. First, for the League of Women Voters in Monroe County, she worked on a national agenda project. Next, for the Girl Scouts of Monroe County, she gave good council and aid in connection with the memorial project: "Lou Henry Hoover Wildlife Sanctuary." Then, for the Seventh District, Federated Garden Clubs of New York State, she helped to evolve the "Genesee Valley Conservation Trail." The last project won a national federation award for the club and she was given a scholarship to the Audubon Camp in Maine.

And when she has not been directing from the chair, she has been wholeheartedly working as a member, and additionally as an individual. For many years she has engrossed scouts on nature walks, in the wooded areas of her home and also in local camps. In 1957 she took a troop on a tour of Europe. We can be sure that the girls were regaled with many aspects of the natural, as well as the political, history of the countries visited. She is still active with the garden federation and, appropriately enough, is working with them in celebrating a special conservation year. As a graduate of Mount Union College, she brings an informed as well as an enthusiastic approach to all of her endeavors.

For so freely sharing her love of botany and nature and contributing so much to conservation education, we most warmly welcome her as a Fellow.

1965

Peter Paul Kellogg, Ph.D.

Honorary Member

Compared to Ornithology, Biological Acoustics, as a scientific discipline, is a fledgling. Like a fledgling, however, it keeps growing. And like any good scientific discipline, its pursuit often raises more questions than it answers.

The Academy at this time wishes to recognize one who has literally been witness to the hatching of the fledgling science of Biological Acoustics and whose tireless quest for answers to the myriad questions raised thereby has resulted in an astonishing array of accomplishments.

By way of answer to a wistfully expressed wish for a record of bird songs that could be repeatedly listened to and enjoyed and studied, he was instrumental in tapping a wide range of resources, including those of Cornell University and its Laboratory of Ornithology, to make such a wish come true. The development of modern techniques of recording sounds in nature was a long and difficult and expensive process. He did not accomplish it single-handed; he is the first to stress the fact that it was a matter of teamwork, cooperation and hard work by many people.

But there can be no doubt that it was his sure grasp, both of the complexities of electronics and the facts of ornithological life, that is in great measure responsible for the existence today of a Cornell Library of Natural Sounds, which contains more than 17,000 selections of the voices of some 1,500 species of animals from all parts of the world. Nor is there any doubt that because of him, records are so readily available now that bird song is a part of nearly everyone's daily life.

Parallel to all these endeavors has been a lifetime of teaching ornithology, of research, and for more than twenty-five years conducting a weekly local broadcast about birds. His present position is Assistant Director of the Cornell Laboratory of Ornithology.

For distinguished eminence in the fields of Ornithology and Biological Acoustics, for outstanding success in bringing the lore of birds and bird song to all, for inspiration and guidance to more than one generation of students, the Rochester Academy of Science considers it a privilege to confer its Honorary Membership on Dr. Peter Paul Kellogg.

Robert G. McKinney

Fellow

Ever since the time of Noah, mankind has known wonder and curiosity about bird migration. For fifteen years, a devoted bander of birds, this candidate has contributed much evidence to the solution of that age-old mystery. Even after having personally caught, banded, recorded, and released some 10,000 birds of many different species, his enthusiasm for a bird in the hand continues unabated. One of the highlights of an early morning mid-May birding expedition is to encounter a setup of mist nets and traps manned by our candidate, who has usually held some of the interesting migrants he has caught for the close-up inspection and delight of other birders.

It is doubtful if he can remember a time when the world of nature was not a strong and compelling lure to him. As a junior member of the Burroughs-Audubon Nature Club, he spent much time at their sanctuary absorbing the lore of birds, plants, and insects that is on tap there. Over the years, he has been constantly active in the affairs of our local nature groups, having served in many capacities, including terms as president and trustee of the Burroughs-Audubon Nature Club and vice-chairman and secretary of the Genesee Ornithological Society. (Ornithology Section of the Academy.)

His energy and enthusiasm had a very considerable part in making Rochester an active co-sponsor with Buffalo and Jamestown of the famous annual Allegheny State Park Pilgrimage, which now attracts some 500 participants in a June weekend of nature field trips and lectures. His abilities as a leader of field trips has gained him a popularity extending far beyond local boundaries. He is presently the Genesee Ornithological Society's delegate to the Monroe County Conservation Council. As a trustee of the Bergen Swamp Preservation Society, he is currently working on that group's land acquisition program.

For his infectious enthusiasms, his able and responsible leadership in many nature study activities, the Rochester Academy of Science is proud to welcome Robert G. McKinney as a Fellow.

Wendell C. Mohr

Fellow

Reversing the time-honored dictum, our present candidate for Academy honors came east as a young man, from Colorado where the proximity of the mineral-rich Rockies gave impetus to and helped shape his life-long avocation of Mineralogy and where he had already gained considerable stature as a collector and exhibitor of rocks and minerals.

Graduation from Rennselaer Polytechnic Institute and employment by Kodak came in 1953 and he presently serves the latter institution as a Technical Services Supervisor. Since his arrival in Rochester, his enthusiastic avocational activities have grown and bloomed and born much fruit. One of his field trip colleagues tells of watching in awe as our candidate personally quarried tons of material in order to obtain the choicest specimens.

His services to the Academy and its Mineral Section have been of many kinds. They include two terms as chairman and much important work on various committees such as the one involved in renovating the Rochester Museum's mineral collections. In the spring of 1964, he initiated and conducted an eight-week course in elementary Mineralogy that proved so popular that it was repeated this spring. He has served as a judge in the Earth Sciences at the Annual Science Congress at Brockport. By sharing his enthusiasms through numerous talks and demonstrations to local Scout and Church groups, he has undoubtedly shaped and guided the interests and talents of many a future rock collector and geologist.

For distinguished service to the Academy and for continuing contributions to the enrichment of our community life, the Rochester Academy of Science is proud to welcome Wendell C. Mohr as a Fellow.

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