
THE EFFECT OF SEWAGE-TREATMENT-PLANT EFFLUENT ON DIATOM COMMUNITIES IN THE NORTH BRANCH OF THE PORTAGE RIVER, WOOD COUNTY, OHIO[1]

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ABSTRACT

The North Branch of the Portage River was sampled by means of artificial substrates in order to determine the effect of sewage-treatment-plant effluent on the diatom communities. The effluent appears to be a source of nitrogen and phosphorus for the river. Diatom-community composition appears to be affected by the effluent; ***Gomphonema parvulum***, in particular, was especially abundant at stations with a high content of Poe Ditch effluent. A total of 111 diatom taxa was observed in this study; 24 of these taxa were previously unreported from Ohio.

INTRODUCTION

The diatom floras of the streams of Ohio are incompletely known. Weber and Moore (1967) and Patrick (1961) investigated diatoms in the Little Miami and Ottawa Rivers, respectively. Collins and Kalinski (in press) recently reviewed

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the Ohio diatom literature, including an extensive study of some southern Ohio streams. Diatom communities of streams draining into Lake Erie from northwest Ohio have largely been neglected. The objectives of this study were to describe the diatom community in a portion of the North Branch of the Portage River and to determine the effect of Poe Ditch, a tributary carrying sewage treatment plant effluent, on that community. Marks (1970) has already described the community of macroscopic bottom invertebrates from this habitat. This is the second of what is hoped to be series of studies on the effect of Poe Ditch on the Portage River ecosystem.

MATERIALS AND METHODS

Study Area

The Portage River drains northward from the Defiance Moraine in northwest Ohio and into Lake Erie. The North Branch of the Portage River, which makes up the western portion of that river's drainage system, is the longest tributary of the system, but has the least gradient—only about three feet per mile (Kaatz, 1955).

The study area was restricted to section 22 of Center Township in Wood County (fig. 1), where the North Branch receives the discharge of Poe Ditch. Poe Ditch contains both field-tile drainage and effluent from the Bowling Green municipal sewage-treatment plant. Owing to combined sanitary and storm sewers in Bowling Green, Poe Ditch may be a source of raw sewage after heavy local precipitation.

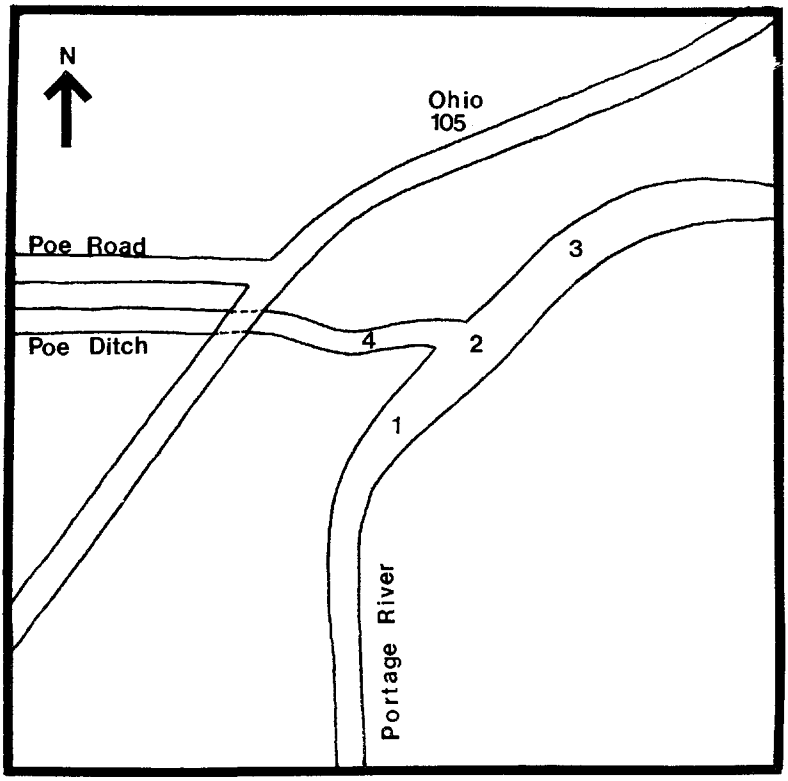

FIGURE 1. Locations of sampling Stations 1, 2, 3, and 4 in the North Branch of the Portage River and Poe Ditch near the intersection of Poe Road and Ohio Route 105. Map is one-half mile square.

Sampling and Analysis

Four stations (fig. 1) were established on the North Branch of the Portage River and on Poe Ditch as follows: Station 1, in North Branch approximately 100 meters upstream from the confluence of Poe Ditch and the North Branch; Station 2, at the confluence of Poe Ditch and the North Branch; Station 3, in North Branch approximately 100 meters downstream from the confluence of Poe Ditch and the North Branch; Station 4, approximately 50 meters back into Poe Ditch from its confluence with the river. Each station was studied from October 15, 1970, through February 4, 1971.

The following chemical and physical parameters were monitored weekly on surface-water grab samples: alkalinity, chloride, nitrate nitrogen, nitrite nitrogen, orthophosphate, pH, sulfate, and turbidity. A direct-reading portable engineers' laboratory (Hach Chemical Company's DR–EL) was employed. Water samples at each station were tested on the same day of each week for comparative purposes. All tests were performed in the laboratory except field-conducted pH checks.

Diatoms were collected biweekly at all four stations by means of a modified Catherwood diatometer like that first described by Patrick, Hohn, and Wallace (1954). Glass microscope slides placed in the diatometer served as a substrate for diatom attachment and growth. Each slide was exposed in the diatometer for two weeks, the exposure period recommended by Patrick, Hohn, and Wallace (1954).

It is recognized that not all members of a natural diatom community will colonize a diatometer (Hohn and Hellerman, 1954). However, many do, and use of such a substrate provided consistent and readily obtained results. In addition, this device helped standardize several physical parameters, including current, substrate, and water depth, among stations. Because of vandalism, high water, and ice destruction, Station 1 was eliminated from the study on January 7, 1971, as was Station 2 on February 4, 1971.

Diatom collections were cleaned according to the method described by Van Der Werff (1955). A portion of each cleaned sample was mounted on a microscope slide employing Hyrax Mounting Medium (R.I. = 1.65).

A slide from each collection was examined and 500 specimens were randomly counted. In all cases, the starting point for the count was the same for each slide. One full field under oil immersion was scanned, beginning at the top left-hand corner of the slide. Additional fields were then viewed until 500 valves had been counted and recorded.

RESULTS

Chemical

Water chemistry at all stations varied throughout the sampling period, but the four stations can best be contrasted by comparing averages of measurements (table 1). Values for alkalinity and pH were typical for northwest Ohio streams, averages for the stations ranging from 188 to 222 ppm and from 7.5 to 8.1, respectively. Average concentrations of nitrate nitrogen, nitrite nitrogen, and orthophosphate increased downstream, but with Poe Ditch having the greatest concentrations.

Biological

A total of 111 diatom taxa was observed from the collections. The distribution and relative abundances of these taxa were quite different among the four stations (table 2). Diatoms were placed into one of four general categories depending on their average relative abundance in the community, as follows: rare—diatom species comprising less than 1%; uncommon—species comprising from 1 to 5%; common—species comprising from 5 to 10%; and abundant—species making up more than 10%. Table 2 lists 24 taxa not previously reported from Ohio (Collins and Kalinski, in press). A representative specimen of each taxon is on deposit in the Bowling Green State University diatom collection.

During the study period, 53 diatom taxa were observed at Station 1. Only 5 of these were present in large enough numbers to average at least 5% of the community (fig. 2A). *Navicula cryptocephala* and *Surirella ovata* were most abundant, both generally increasing in relative abundance during the sampling period. Other taxa consistently present in large numbers were *Navicula crypotcephala* var. *veneta*, *Nitzschia acicularis*, and *N. palea.* All other diatoms recorded at this station were uncommon or rare.

TABLE 1

Minimum, average, and maximum concentrations of chemical parameters in parts per million

	Stations				
	1	2	3	4	
Total alkalinity (ppm CO_3)	190	120	110	130	min.
	222	198	188	188	ave.
	310	270	270	280	max.
pH	7.5	7.3	7.5	7.0	min.
	8.1	7.8	7.8	7.5	ave.
	8.4	8.4	8.3	8.0	max.
Nitrate nitrogen (ppm)	2.0	2.5	4.0	3.0	min.
	7.9	8.3	8.8	9.4	ave.
	14.0	15.0	15.0	18.0	max.
Nitrite nitrogen (ppm)	0.03	0.17	0.23	0.56	min.
	0.19	0.51	0.81	0.91	ave.
	0.99	1.45	1.45	1.49	max.
Orthophosphate (ppm)	0.2	0.1	3.2	4.8	min.
	1.2	5.3	7.3	7.8	ave.
	4.6	10.0	11.6	11.0	max.
Sulfate (ppm)	210	200	210	180	min.
	359	282	282	239	ave.
	490	400	420	310	max.

The attached diatom community at Station 2, at the confluence of Poe Ditch and the Portage River, consisted of 64 taxa over the study period. The only common or abundant members were ***Gomphonema parvulum***, ***Navicula cryptocephala***, ***N. cryptocephala*** var. ***veneta***, ***Nitzschia palea***, and ***Surirella ovata*** (fig. 2B). ***Surirella ovata*** increased steadily in relative abundance over the sampling period, and attained its greatest relative abundance, 58%, on January 20.

A total of 72 taxa, only 5 of which were common or abundant, was observed at Station 3: ***Gomphonema parvulum***, *Navicula cryptocephala*, *Nitzschia accomodata*, *N. palea*, and ***Surirella ovata*** (fig. 2C). As at Station 2, *S. ovata* increased in relative abundance through the sampling period and became the most abundant diatom from December 23 through February 4.

At Station 4, in Poe Ditch, 83 taxa of diatoms were observed during the course of the study. Only 2 species were present in large enough numbers to be considered common or abundant (fig. 2D): ***Gomphonema parvulum***, which showed no seasonal preference, and *Nitzschia palea*, which was most abundant in October and November.

DISCUSSION

Of the 111 taxa of diatoms observed in this study, less than 30% were common to all four stations. This was probably due in part to differences in the physical

TABLE 2

Diatoms observed at sampling stations during study[1]

Diatom taxa	Stations			
	1	2	3	4
Achnanthes affinis Grun. var. *affinis**	—	—	R	R
A. lanceolata (Bréb.) Grun. var. *lanceolata*	R	R	R	R
A. lanceolata var. *dubia* Grun.	R	R	R	R
Amphora ovalis Kütz. var. *ovalis*	—	—	—	R
A. submontana Hust. var. *submontana*	R	R	R	R
A. veneta Kütz. var. *veneta*	—	R	—	—
Caloneis bacillum (Grun.) Cl. var. *bacillum*	—	—	—	R
Cocconeis pediculus Ehr. var. *pediculus*	—	—	R	—
C. placentula Ehr. var. *placentula*	—	R	R	—
C. placentula var. *euglypta* (Ehr.) Grun.	R	R	—	—
Cyclotella atomus Hust. var. *atomus*	—	R	—	—
C. comta (Ehr.) Kütz. var. *comta*	—	R	—	R
C. meneghiniana Kütz. var. *meneghiniana*	R	R	R	U
Cymbella sinuata Greg. var. *sinuata*	—	—	—	R
C. spp. No. 1	R	—	—	R
C. turgida Greg. var. *turgida*	—	—	—	R
C. ventricosa Kütz. var. *ventricosa*	—	R	R	—
Diatoma hiemale (Roth) Heib. var. *hiemale**	—	R	—	—
Fragilaria construens (Ehr.) Grun. var. *construens*	—	R	—	R
F. construens var. *binodis* (Ehr.) Grun.*	R	—	R	R
Gomphonema olivaceum (Lyngbye) Kütz. var. *olivaceum*	R	U	U	C
G. parvulum (Kütz.) Grun. var. *parvulum*	U	C	A	A
Gyrosigma acuminatum (Kütz.) Rabh. var. *acuminatum*	R	R	R	R
G. macrum (W. Sm.) Griff & Henfr. var. *macrum**	R	R	R	R
G. obtusatum (Sulliv. & Wormley) Boyer var. *obtusatum*	—	—	R	—
G. scalproides (Rabh.) Cl. var. *scalproides*	—	—	R	—
Hantzschia amphioxys (Ehr.) Grun. var. *amphioxys*	—	—	—	R
Meridion circulare Ag. var. *circulare*	—	R	R	R
Navicula accomoda Hust. var. *accomoda*	R	U	U	U
N. atomus (Naeg.) Grun. var. *atomus*	R	R	—	R
N. capitata Ehr. var. *capitata*	U	R	R	R
N. capitata var. *hungarica* (Grun.) Ross	R	—	—	—
N. capitata var. *luneburgensis* (Grun) Patr.*	—	—	—	R
N. cincta (Ehr.) Kütz. var. *cincta*	—	—	R	—
N. contenta var. *biceps* Arn.	—	—	R	R
N. cryptocephala Kütz. var. *cryptocephala*	A	A	C	U
N. cryptocephala var. *veneta* (Kütz.) Grun.	A	C	U	R
N. cuspidata Kütz. var. *cuspidata*	—	—	R	R
N. cuspidata var. *ambigua* (Ehr.) Cl.	—	—	R	—
N. gastrum Ehr. var. *gastrum*	—	—	—	R
N. heufleri Grun. var. *heufleri**	—	R	R	R
N. heufleri var. *leptocephala* (Breb. ex Grun.) Patr.*	U	U	R	R
N. insociabilis Krasske var. *insociabilis**	—	—	—	R
N. lanceolata (Ag.) Kütz. var. *lanceolata*	R	R	R	R
N. luzonensis Hust. var. *luzonensis*	—	—	R	R
N. menisculus Schumann var. *menisculus*	R	R	R	R
N. menisculus var. *upsaliensis* (Grun.) Grun.	R	R	R	R
N. minima Grun. var. *minima*	—	—	R	R
N. minuscula Grun. var. *minuscula*	—	R	R	R
N. muralis Grun. var. *muralis**	—	—	R	R
N. mutica Kutz. var. *mutica*	R	R	R	R
N. mutica var. *tropica* Hust.*	—	R	R	R
N. mutica var. *undulata* (Hilse) Grun.*	—	—	—	R
N. pelliculosa (Bréb.) Hilse var. *pelliculosa*	—	—	—	R
N. peregrina (Ehr.) Kütz. var. *peregrina**	—	—	R	—
N. placentula (Ehr.) Grun. var. *placentula**	—	R	—	—
N. pupula Kütz. var. *pupula*	—	—	R	R
N. pupula var. *elliptica* Hust.	—	—	—	R
N. pygmea Kütz. var. *pygmea*	—	—	R	R

TABLE 2. *Continued*

Diatom taxa	Stations 1	2	3	4
N. rhynchocephala Kütz. var. *rhynchocephala**	U	R	R	R
N. salinarum Grun. var. *salinarum*	R	—	R	—
N. salinarum var. *intermedia* (Grun.) Cl.	—	—	—	R
N. seminulum Grun. var. *seminulum*	R	R	R	R
N. seminulum var. *hustedtii* Patr.*	R	R	R	R
N. spp. No. 1	R	R	R	R
N. spp. No. 2	—	—	R	—
N. spp. No. 3	—	—	R	—
N. tripunctata (O. F. Mull.) Bory var. *tripunctata*	R	R	R	R
N. tripunctata var. *schizonemoides* (V. H.) Patr.	R	R	R	R
N. viridula var. *avenacea* (Bréb.) Grun.*	—	—	R	—
Nitzschia accomodata Hust. var. *accomodata**	U	U	C	U
N. acicularis W. Sm. var. *acicularis*	A	U	U	R
N. acuminata (W. Sm.) Grun. var. *acuminata**	—	R	—	—
N. amphibia Grun. var. *amphibia*	—	R	U	U
N. angustata (W. Sm.) Grun. var. *angustata*	—	R	—	—
N. angustata var. *acuta* Grun.	R	—	—	—
N. apiculata (Greg.) Grun. var. *apiculata*	—	R	R	—
N. baccata Hust. var. *baccata**	R	R	R	—
N. capitellata Hust. var. *capitellata*	R	R	R	R
N. communis Rabh. var. *communis**	—	R	—	—
N. commutata Grun. var. *commutata*	R	—	—	R
N. denticula Grun. var. *denticula**	—	R	R	R
N. dissipata (Kütz.) Grun. var. *dissipata*	U	R	R	R
N. filiformis (W. Sm.) Hust. var. *filiformis*	—	—	R	R
N. fonticola Grun. var. *fonticola*	R	R	R	R
N. frustulum Kütz. var. *frustulum*	R	R	U	U
N. frustulum var. *subsalina* Hust.*	R	—	—	—
N. hungarica Grun. var. *hungarica*	U	U	U	R
N. linearis W. Sm. var. *linearis*	U	U	U	U
N. palea (Kütz.) W. Sm. var. *palea*	C	C	A	A
N. palea var. *tropica* Hust.*	R	—	R	R
N. sigma (Kütz.) W. Sm. var. *sigma*	R	U	R	U
N. sigmoidea (Ehr.) W. Sm. var. *sigmoidea*	U	R	U	R
N. thermalis Kütz. var. *thermalis*	U	U	U	U
N. thermalis var. *minor* Hilse	—	—	—	R
N. tryblionella Hantzsch var. *tryblionella*	R	R	R	R
N. tryblionella var. *levidensis* (W. Sm.) Grun.	—	—	R	R
N. spp. No. 1	U	—	R	R
Pinnularia brebissonii Kütz. var. *brebissonii**	—	—	R	—
P. spp. No. 1	—	—	—	R
Rhoicosphenia curvata Kütz. var. *curvata*	—	R	R	R
Stauroneis anceps Ehr. var. *anceps*	—	—	—	R
S. anceps f. *linearis* (Ehr.) Hust.*	—	—	—	R
S. spp. No. 1	—	—	—	R
Stephanodiscus astrea (Ehr.) Grun. var. *astrea*	—	—	R	R
S. astrea var. *minutula* (Kütz.) Grun.	—	—	—	R
Surirella ovata Kütz. var. *ovata*	A	A	A	U
S. ovata var. *crumena* (Breb) V. H.	R	R	R	R
S. ovata var. *pinnata* W. Sm.	R	R	R	R
Synedra fasciculata (Ag.) Kütz. var. *fasciculata*	R	R	—	—
S. ulna (Nitzsch) Ehr. var. *ulna*	R	R	—	U

A = abundant, ave. relative abundance >10%
C = common, ave. relative abundance 5–10%
U = uncommon, ave. relative abundance 1–5%
R = rare, ave. <1%
— = not observed
* = new Ohio record

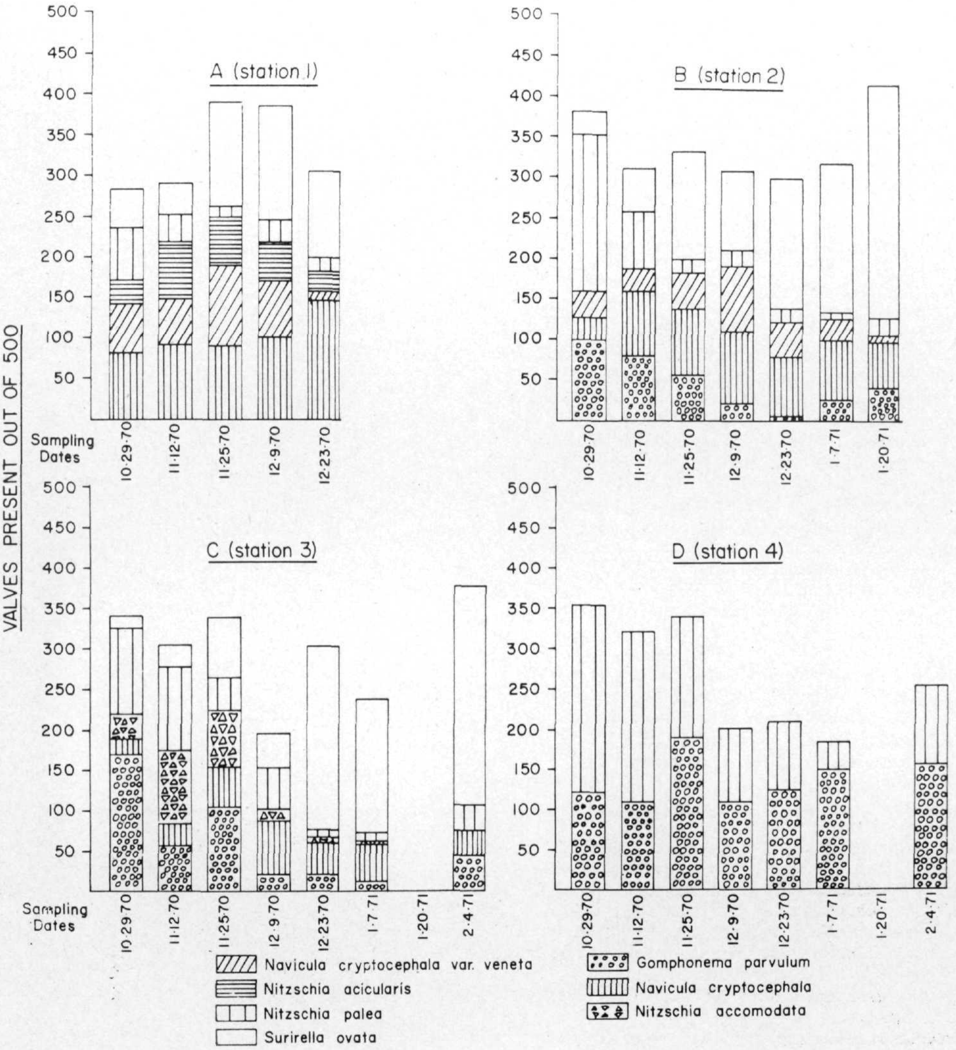

FIGURE 2. Seasonal relative distribution of seven most abundant species of diatoms at stations in the North Branch of the Portage River and in Poe Ditch.

nature of the stream bed. At Station 1, upstream from the outfall of Poe Ditch, the stream bed is somewhat gravelly, in contrast to a more silty bed at downstream Stations 2 and 3, which are influenced by the outfall of Poe Ditch. This certainly could have affected the composition of local natural diatom species colonizing the diatometers.

The most obvious chemical differences among stations were the increased concentrations of nitrite nitrogen, nitrate nitrogen, and orthophosphate downstream. The sewage effluent in Poe Ditch undoubtedly had many other undocumented effects on the chemical environment of the river, but changes in the diatom communities are difficult to associate with individual chemical parameters in an uncontrolled situation.

The only diatoms common or abundant at Station 4 (in Poe Ditch) were *Gomphonema parvulum* and *Nitzschia palea*. These organisms have been considered by several authors (Butcher, 1947; Cholnoky, 1968; and Lowe, 1972) to be tolerant of (or stimulated by) organic enrichment. It is interesting to note that *G. parvulum* was present in large numbers only in Poe Ditch and at those Portage River stations below its outfall and was uncommon at Station 1, indicating that this species is probably affected positively by Poe Ditch effluent. *Nitzschia palea* appears to be more tolerant of, rather than dependent upon, the high nutrient concentrations of Poe Ditch. This species was abundant in Poe Ditch, but was common at all other stations, including Station 1, which is free of the chemical influence of Poe Ditch.

Surirella ovata was the most abundant diatom from the winter Portage River collections. It was uncommon in Poe Ditch, suggesting a lack of tolerance by the species for concentrated sewage effluent. Its appearance at downstream stations suggests that it may be tolerant of the effects of diluted sewage effluent.

The length of the river that is affected by Poe Ditch effluent was not determined, but nutrient enrichment from the Bowling Green sewage-treatment plant appears to play a significant role in determining relative abundances of diatom community members in the portion of the Portage River studied.

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The Armillary Sphere. Designed by *Seymour Robins.* Universe Books, New York. (booklet and folding paper model). 1973. 16 p. $2.95.

This booklet and paper model are available in a package which also contains an attractive envelope and seal for gift mailing. The folding paper sculpture is ingeniously constructed to open into a free-standing representation of an armillary sphere. The booklet contains a concise account of the history of the armillary sphere as an astronomical measuring, computing, and teaching device. There are twelve illustrations of representative armillary spheres from the time of Ptolemy to the late 18th century. There is one slightly confusing typographical error in the caption to Figure 12, in which Ptolemy's system, rather than Johann Müller, is referred to as Regiomontanus.

The Robins' Armillary Sphere is intended primarily as an interesting and unusual ornamental gift, but the booklet provides additional instructive commentary. My only criticism is the lack of bibliography or references to which an interested recipient of this gift might turn for further enlightenment.

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