E. Treiber, Ed. (Springer, Berlin, 1957), p. 439.
7. B. M. Afzelius, *Botan. Notiser* **108**, 128 (1955).
8. ———, *Grana Palynologica* **1** (2), 22 (1956).
9. L. G. Labouriau *et al.* [see K. Steffren, *Z. Botan.* **43**, 346 (1955)] gave evidence for weak x-ray interference patterns (Debye-Scherrer rings) on acid- and alkali-treated spores of *Lycopodium clavatum* and *Anemia callina* and pollen of *Gladiolus communis*. Negative results were reported for *Hibiscus tiliaceus* and *Lilium longiflorum*. As pointed out in the review by Steffen (see above) the results are open to criticism, since a negative result for *Anemia* was reversed after a longer exposure, but they do suggest that the polymeric crystallinity of sporopollenin is influenced by chemical reagents and physical factors, such as heat, which do not alter the microscopic morphology of the exine. Labouriau *et al.* attributed the variation in results to differential stability of sporopollenin in acids and hydroxides. Differences in solubility, autoxidation, and sporopollenin content have been reported for exine material from various species (see reviews *2*, *4*).
10. F. Zetzsche and H. Vicuri, *Helv. Chim. Acta* **14**, 58 (1931).
11. I. W. Bailey, *J. Arnold Arbor.* **41**, 141 (1960).
12. B. M. Afzelius, G. Erdtman, F. S. Sjöstrand, *Svensk Botan. Tidskr.* **48**, 155 (1954).
13. G. Erdtman, *Statens Naturvetenskapliga Forskningsråd Arsbok* **8**, 139 (1953–54); P. Sitte, *Mikroskopie* **8**, 290 (1953).
14. H. G. Ehrlich, *Exptl. Cell Res.* **15**, 463 (1958); D. A. Larson and C. W. Lewis, *Am. J. Botany* **48**, 934 (1961).
15. J. Ueno, Inst. Polytech. Osaka City Univ. *Ser. D*, **10**, 75 (1959); *Nara Joshi Daigaku Seibutsu Gakkaishi* **10**, 19 (1960).
16. G. Erdtman, *Svensk Botan. Tidskr.* **46**, 174 (1952); J. R. Rowley, K. Mühlethaler, A. Frey-Wyssling, *J. Biophys. Biochem. Cytol.* **6**, 537 (1959).
17. This work was supported by grants from the National Science Foundation (G6080 and 13128) and funds from the University of Massachusetts Research Council. I wish to express my appreciation to Professors A. Frey-Wyssling and K. Mühlethaler at the Swiss Federal Institute of Technology, Professor C. E. Hall at Massachusetts Institute of Technology, and Professors A. W. Frenkel and A. O. Dahl at the University of Minnesota for providing space and equipment for this study.

6 February 1962

Radiocarbon Ages of Postglacial Lake Clays near Michigan City, Indiana

Abstract. Two radiocarbon dates were obtained for postglacial clays. One sample, 6350 years old, was taken from a bed of compacted and carbonized wood just above a bed of pebbly clay. Overlying the woody bed is 5½ feet of organic bluish clays and beach sands near the present lake level. The upper clay layer contained a younger wood sample, 5475 years old. The blue clays are of shallow swamp origin and were deposited during the late low-water stage of Lake Chippewa; the pebbly clay is assumed to be of Glenwood age (about 11,000 years) or older.

Erosion caused by the present low level of Lake Michigan recently exposed postglacial lake clays 2 miles west of Michigan City, Indiana (Sec. 30, T. 28 N., R. 4 W.). The clays are exposed for about a mile along the shore. The beds are up to 5½ feet thick. Semicircular fractures in the clays are now visible along the entire exposure (*1*). A plastic yellowish-gray clay with pebbles of various sizes underlies the blue clay. Its top surface shows polygons up to 1 foot in diameter; occasional contortions of the beds sometimes resemble folds. A discontinuous bed of strongly carbonized compressed wood was temporarily exposed immediately above the yellowish-gray clay. The carbon-14 age of this wood is 6350 ± 200 years (*2*). About 3¾ feet of dark blue, carbonaceous, fossiliferous clay, in beds 6 to 15 inches thick, overlies both the wood and the lower pebbly clay. Stratified sand up to 2 feet thick is wedged between the lower blue clay beds and a layer of compacted organic clay 10 inches thick which forms the top of the lacustrine series in most places. The top bed, however, edges out laterally into overlying cross-bedded sand. A few pieces of lightly carbonized wood gave the second carbon-14 age for the upper clay bed, 5475 ± 250 years (*2*). Formerly I believed that the clays were deposits of an earlier Lake Chicago high-water stage (*3*). (Figure 1 shows a cross section through the clays exposed west of Michigan City, Indiana.)

In the following discussion the radiocarbon dated clay beds near Michigan City are compared with dated peat deposits near South Haven, Michigan, 60 miles north of Michigan City, described by Zumberge and Potzger (*4*). The South Haven sequence starts with a blue silt at about Lake Michigan level (580 feet above sea level). Contorted laminae are tentatively interpreted as glacial involutions. Wood located just above the silt showed a radiocarbon age of 11,000 years. On the basis of this age, Zumberge and Potzger assign the silt to the Glenwood low-water stage of Lake Chicago. The water-laid silt subsequently became exposed to extensive frost action during the following Bowmanville low-water stage (less than 580 feet above sea level) which caused the involutions. At Michigan City the top of the pebble-containing yellowish clay is found near the present lake level and is older than 6300 years.

Vertical cracks in this clay form small irregular polygons which strongly resemble frost polygons of arctic soils. The local foldlike contortions as well as the polygons are believed to have occurred during the first low-water stage of Lake Chicago; this stage offered the only contact with arctic climate. The clay was covered with at least 10 feet of water or ice following the Glenwood time, which prevented the exposure to heavy frost action then. Again the clays became exposed during the beginning of the Lake Chippewa low-water stage at a time near the hypsothermic postglacial warm weather peak described by Flint and Brandtner (*5*). The occurrence of frost features, therefore, does not appear to be possible during Lake Chippewa time. The yellowish-gray clay of Michigan City is, therefore, believed to be of Glenwood or pre-Glenwood age.

At South Haven, a few feet of bedded sands occur between the blue silt and a 30-inch-thick peat bed. Several carbon-14 ages of the entire peat deposit range from 8305 ± years at the

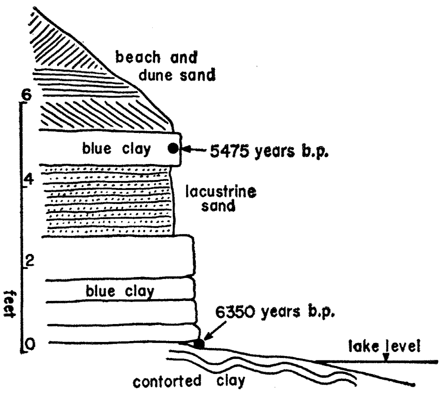

Fig. 1. Cross section through the clays near Michigan City, Indiana.

years before present	Lake Stage (elev. above sea level)		South Haven	Michigan City
0	Lake Michigan	580		
2500	Algoma	595		
3500	Nipissing	605		
4000				blue clay
6000	Chippewa	230	peat	
8000				
8500	Algonquin	605	beach sand	
	Nipissing	605		
	Calumet	620		
11000	Bowmanville bel.	580	contorted silt	contorted clay
	Glenwood	640		
13000				

Fig. 2. Comparison of the Michigan City and South Haven sites based on the Correlation Chart of Geologic Events by Zumberge and Potzger (*4*).

bottom to 4000 years near the top. The lateral extension of the peat is only several feet wide and was laid down in bogs far offshore during the entire duration of the Lake Chippewa low-water stage. At Michigan City, 5½ feet of organic fossiliferous clays and some shallow-water sands were deposited above the yellowish-gray clays in shallow lakes and marshes during the later part of Lake Chippewa time, between 6300 and 5475 years ago. The shoreline of Lake Chippewa has shifted probably a few miles to the west into the present Lake Michigan. Numerous grass fragments and the presence of the ostracod genus *Cyclocypris* strongly suggest marsh environment.

Dated shallow-water deposits of the Lake Chippewa low-water stage are exposed at both localities. The lake level was about 280 feet below the present level then. The extensive outcrops of the blue fossiliferous clays in Michigan City are remnants of a shallow-water deposit which was much more extensive than the peat-producing bog near South Haven. The lakes which developed in shallow depressions on older beach sands were dammed up by former fore-dunes and overflowed or drained out through the dunes into Lake Chippewa. The subsequent rise of the water level to the Lake Nipissing stage, about 25 feet above the present lake level, must have caused extensive erosion of the clays. The final drop of the lake level from the Algoma lake stage to the present lake level about 2500 years ago renewed the erosional process of the clays. Recent construction of jetties and breakwaters intensified erosion at the Michigan City harbor near the clay outcrop (*6*).

ERHARD M. WINKLER
Department of Geology, University of Notre Dame, Notre Dame, Indiana

References and Notes

1. R. C. Gutschick, B. Voight, E. M. Winkler, "Circular fractures in Pleistocene clays along Lake Michigan, Indiana," *Bull Geol. Soc. Am.*, abstract (in press).
2. The radiocarbon ages were determined by Isotopes, Inc., Westwood, N.J., October 1961. Their numbers are I-362 for the upper wood sample 5475-250 and I-363 for the lower wood sample 6350-200.
3. J. L. Hough, "Pleistocene chronology of the Great Lakes region," mimeographed report, Urbana, Ill., 1955, Office of Naval Research, Contract No. NGori-07133, Project NR-018-122.
4. J. H. Zumberge and J. E. Potzger, *Bull. Geol. Soc. Am.* **67**, 277 (1956).
5. R. F. Flint and F. Brandtner, *Am. J. Sci.* **259**, 321 (1961).
6. Thanks are due to R. C. Gutschick for valuable suggestions.

12 March 1962

Visual Depth Perception of a 10-Month-Old Monocular Human Infant

Abstract. A monocular infant tested on the "visual cliff" crawled over glass which had a patterned surface just beneath it and would not cross glass which had the same pattern 40 inches below its surface. Since this infant, using only monocular visual cues, was able to discriminate depth, the experiment disproves a general belief in the primacy of binocular cues in depth perception.

It is a "common sense" view that binocular vision is necessary for proper depth perception. Binocular disparity can be shown, by itself, to yield an impressive depth effect through the use of stimulus cards in a stereoscope. While stereopsis can be a sole determinant of depth, it is not necessarily the only or the primary determinant of depth perception in everyday life. Textbook writers usually list both binocular cues (binocular disparity and convergence) and monocular cues (monocular parallax, accommodation, aerial perspective, linear perspective, and so forth), and rarely try to assess the importance of each. Ophthalmologists are more prone to stress the primacy of binocular cues (*1*); psychologist J. J. Gibson (*2*) has stressed for a long time the importance of monocular factors—in particular, monocular motion parallax and differential gradients of texture in the environment.

Gibson and Walk have used the "visual cliff" to show that binocular human infants can discriminate depth as soon as they can crawl (*3*). Our investigation was an empirical one to determine whether a monocular infant can discriminate depth on the visual cliff. This infant's ability to discriminate visual depth may help disprove a general belief in the primacy of binocular factors.

The visual cliff apparatus for testing infants is a large, hollow, rectangular box topped with glass, 8 feet long by 6 feet wide and 40 inches high. The inside surface of the box (bottom and four sides) is painted gray; the top is covered with ½-inch thick Herculite glass. A 12-inch wide center board divides the glass into two segments each about 4 by 6 feet. Flush under the glass on one side of the center board (the "shallow" side) is a checked pattern. The same pattern is placed 40 inches below the glass on the other, the "deep," side.

Only visual cues differentiate the "shallow" and the "deep" sides. Tactual, auditory and olfactory cues are equalized by the glass. Since the apparatus is enclosed on the deep side, no familiar objects, such as the feet and legs of the mother, serve as cues to distance. Motion parallax and texture density remain. The gray sides of the apparatus project a fairly homogeneous, indefinite texture. While surface textures on the deep and shallow sides are the same, the surface texture on the deep side projects a finer optical texture.

The female infant was 10½ months old when tested. Cancer (retinoblastoma) had necessitated surgical removal of her right eye when she was 5½ months old. This eye had been blind for an unknown period before the operation. A tumor from the left (sighted) eye had been removed 1 week before the right eye was removed.

During testing the infant was placed on the center board; the mother called her alternately from the shallow and the deep sides. When the infant was placed on the board from the west, the sighted eye was toward the deep side; when she was placed on from the east, the eye was toward the shallow. The mother twirled a tinkling pinwheel and urged the infant to come to her. The procedure follows:

Trial 1. (Infant placed on center board in a sitting position from the west. Mother called from shallow side.) The infant immediately crawled off the center board, over the shallow side, and reached the mother 15 seconds after the start of the trial.

Trail 2. (Infant placed on board from west. Mother called from deep side.) The infant crawled onto the shallow side at once and reached the pinwheel in 12 seconds. The mother called again from the deep side. She went back toward the mother, looked down into the "void," and backed away. She watched the pinwheel being twirled by the mother and reached a hand toward it. Then, she started crawling around on the shallow side and continued until the trial terminated at 3 minutes.

Trial 3. (Infant placed on board from east. Mother called from shallow side.) The infant looked over quickly to the deep side, crawled off the center board, and reached the mother within 5 seconds.

Trial 4. (Infant placed on board from east. Mother called from deep side.) The infant crawled immediately onto the shallow side. She alternated between crawling to the center board,