tential vegetation near the sites is grama-buffalo grass. This distribution coincides with a slightly lower rainfall to the west of the area, with the contact between the two potential-vegetation zones approximately equal to the present 36-cm isohyet (*5*). The steppe includes a number of the floral elements that characterize the early levels of the sequence, such as grasses, chenopods, *Artemesia*, and *Ephedra*. The relatively high percentages of Compositae in these early levels may indicate somewhat more arid conditions similar to those of the desert grassland (*6*) to the south of the area. In contrast, the zone of grama-buffalo grass appears typical of the latest portion of our sequence, lacking such genera as *Artemesia* and *Ephedra* and abundant in grasses (*4*).

The recomputed pollen profile also appears to coincide well with specific faunal evidence from the cultural sequence. The first appearance of significant fragments of bone identifiable as of *Bison* is in test P4B-2, following the first Gramineae peak; it appears to indicate the first major intrusion of bison into the area, and, with the second peak in Gramineae, bison bone becomes the dominant element in faunal refuse. This fact strongly suggests that the pollen changes seen in the revised diagram reflect a valid sequence of climatic changes that resulted in replacement of a slightly more arid flora by the present potential-vegetation pattern.

The significance of these correlations, even within this small sample, indicates that this type of analysis may be widely applicable to problems of paleoclimatic interpretation. Such correlations probably could be most successfully utilized in marginal areas in which diversified economic activities were practiced, rather than in areas of more intensive cultivation where the relatively great quantities of sherds might obscure the relations of the other materials. Further testing will be possible on recovery of adequate samples of fragments of the three classes of cultural materials and pollen from uniform excavation units in midden debris.

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References and Notes

1. P. S. Martin, "Pollen analysis of prehistoric middens near Fort Sumner," Contrib. 55, Program in Geochronology, University of Arizona.
2. H. M. Blalock, *Social Statistics* (1960), p. 287.
3. Certainly the "significance" of a correlation coefficient between quantities expressed as percentages of the same total is subject to constraint, in contrast with correlations between proportions of independent systems (that is, pollen and artifact). Therefore the significance of the correlations within the artifact group and within the pollen group should be viewed with caution.
4. A. W. Kuchler, *Potential Natural Vegetation of the Coterminous United States* (Amer. Geog. Soc. Spec. Publ. 36, 1964).
5. U.S. National Resources Planning Board, *The Pecos River Joint Investigation* (1942), pl. 2.
6. E. F. Castetter, *New Mexico Quart.* **26** (3), 261–65 (1956).
7. The archeological and palynological collections were made in 1960 with the support of NSF grant G-13037, which also enabled analysis of the pollen samples by P. S. Martin, Geochronological Laboratories, University of Arizona. For assistance or advice I thank W. S. Benninghoff, M. B. Davis, R. I. Ford, D. E. Helmich, F. B. Livingstone, P. S. Martin, and James Schoenwetter. An earlier version of the report was presented before the 30th annual meeting of the Society for American Archaeology at Urbana, Ill., 8 May 1965.

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Ultracentrifuge Schlieren Photographs: Automatic Analysis

Abstract. *Schlieren photographs can be digitized and stored in a computer's memory. A computer program then interprets and measures the Schlieren curve and calculates molecular properties.*

The analytical ultracentrifuge is frequently employed to determine the various molecular parameters of large molecules (*1*). Concentration gradients are photographed on a spectroscopic plate by means of a schlieren optical system. The schlieren image is then measured on the microscope with a micrometer stage, and the pairs of values of the coordinates of the sequence of points along the curve are used, together with experimental constants, to calculate desired molecular properties such as sedimentation coefficient, weight-average molecular weight, diffusion coefficient, friction factor, and activity of solute. The work of measuring the spectroscopic plates, the calculations, and making the associated graphs usually takes much longer than the time required for the experiment itself. We now describe a method of shortening some of this work.

The image to be scanned is recorded on film of 35 mm or equivalent size, which is placed in a flying-spot scanner —a FIDAC (*2*). A beam of electrons excites a small spot on the face of a cathode-ray tube, from which spot the light is focused through the film and measured by a sensitive phototube. The amount of light transmitted from the spot, through the film, to the phototube is stored in the computer's core memory at a location that corresponds to the location of the spot on the film; the amount is coded by a number between 0 and 6, corresponding to seven different gray levels in the film. The spot is moved across the face of the cathode-ray tube to produce a raster, thus scanning the entire photographic image.

Once the entire image is in the memory, the picture is interpreted by a program written in a computer-programming language called BUGSYS (*3*); the program creates hypothetical "bugs" at points in the picture stored in the memory, which are such that they can read the number corresponding to the gray level at any point and perform simple motions on command—such as moving up, down, left, or right; finding the center of a thick line; or finding the end of a line. Two such bugs were used, acting together, to locate the origin of axes and coordinates of more than 100 pairs of points on the picture, which points represent values for x_i and the corresponding Δy_i between solution and solvent curves on the schlieren image (see Fig. 1). This schlieren curve represents the solution of the transport equation. The contrast on the spectroscopic plates is such that the photographic image does not have a sharp black-white edge; it changes gradually from dark to light to dark again. The BUGSYS program determines the gray level of each point of the image and the coordinate value for the center of the line (midway between the locations of points of equal gray level). The pairs of values of the coordinates thus determined are used in the same fashion as would be the data obtained by manual measurement of the spectroscopic plate with a comparator: the measured distances are converted to centimeters and used, together with constants for the temperature, angular velocity, and partial specific volume and the ideal gas constant, for numerical solution of the transport equation.

The advantage of this method is in reducing time spent on the work to less than 1 second; it also makes it practicable to pool computer programs and algorithms (or soft ware) from several laboratories and to have these used correctly, even though the investigator may not be in constant touch with

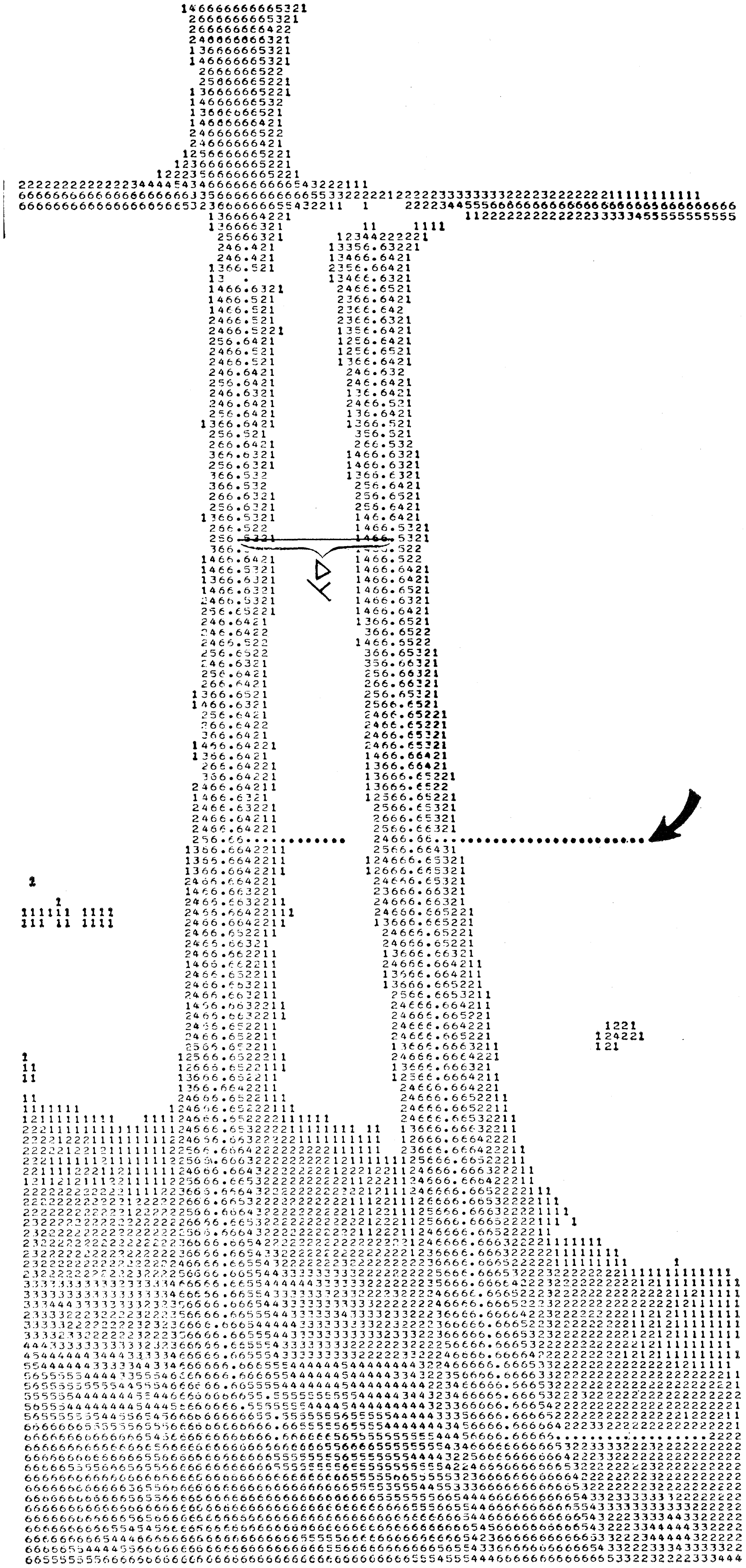

Fig. 1 (left). Computer printout of digitalization of a scanned schlieren photograph. The number at each point represents the density of the corresponding point on the photograph, in one of seven gray levels (the 0-level appears as a blank). The computer measures the magnitudes of Δy, the distance between the two curves at more than 100 points on the curves. The dots represent the "footprints" of the two bugs that were programmed to perform the analysis. One bug was started at the arrow and moved across until it found the center of the right-hand curve; it then initiated another bug that moved across to find the center of the next curve, the x-axis. The two bugs then marched along their respective curves, measuring the Δy distance as shown in the diagram.

the computational aspects of the problem. Moreover, one may now obtain many desirable numbers that hitherto were neglected because of lack of time —for example, internal image processing and computational checks, uncertainty to be attached to the final numerical result, and corrections for certain second-order effects such as compressibility of the solvent, dependence of the activity of the solute on its concentration, solute-solvent interactions, noninstantaneous acceleration time, Johnston-Ogston effect for heterogeneous systems, elastic rotor stretching, and adiabatic cooling of the rotor during acceleration.

One disadvantage is that the method requires a photograph of higher quality than is otherwise necessary: background fog, especially nonconstant background fog, cannot be handled by a simple BUGSYS routine. Since the points are the analog solutions of well-behaved continuous functions, it should be possible either to use the first solution as the first step of an iterative solution and reread the plates by use of this knowledge, or to autocorrelate the coordinates of the points. (Ultimately it will be possible to assemble a system such that, if an investigator learns a computer language consisting of six to twelve words with which he can specify a large number of different kinds of calculations that he wishes, he can easily write a program to obtain the results he wants.)

In summary, our method seems feasible as a general approach to processing schlieren images and to the computation of data measured from them.

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References

1. H. K. Schachman, *Methods Enzymol.* **4**, 32 (1957).
2. R. S. Ledley, *Science* **146**, 216 (1964).
3. ———, J. Jacobsen, M. Belson, *Comm. Assoc. Comput. Machinery* **9** (2), 79 (1966).

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Uric Acid, Uric Acid Dihydrate, and Urates in Urinary Calculi, Ancient and Modern

Abstract. *Uric acid, uric acid dihydrate, and ammonium acid urate occur in bladder stones both ancient and modern. They are seldom abundant in stones from technically developed areas. Urates are usually confined to children's endemic bladder stones; uric acid dihydrate is rare, but uric acid used to be common in bladder stones from elderly men.*

Uric acid was a major constituent of vesical calculi 100 years and more ago. For instance, a "Catalogue of the Collection of Calculi of the Bladder removed by Operation by Sir Henry Thompson FRCS (1893)" (*1*) tabulates details of 1007 stones (1854–1892), all weighing over 20 grains, 977 from adult males, 13 from adult females, 16 from boys, and one from a girl (names, ages, and after-history given). Of these, 571 consisted of pure uric acid, 97 of mixed uric acid and phosphates. Urates (mixed with oxalates) were found in only 36 stones, oxalates (pure or mixed with urates or phosphates) in 89, phosphates in 362 (247 pure), cystine in three. No mention is made of hydrates; for example, whewellite (calcium oxalate monohydrate) and weddellite (2 to 2½ water per formula weight of calcium oxalate) are not listed separately. Thompson's patients were not typical. Most of them were over 60 years of age. They were probably wealthy.

Details of the uric acid and urate content of some other collections, given in Table 1, show that even among ordinary hospital patients, uric acid stones used to be common, though more so in men than in boys (stones were and are rare in females). Urates were common in children. In modern stones, ammonium acid urate is now common from children in the endemic bladder stone areas only. Uric acid is generally a minor constituent, although amounts of up to 17 percent have been reported from Stockholm (*2*) and Chicago (*3*).

Formerly, bladder stones were predominant and kidney stones were rare. This is still true in the endemic stone belts, but the reverse is now the case in North America and most western European countries (*4*). The only collection of renal stones from children that we have examined (*5*) contained a relatively high proportion of ammonium acid urate, but only one stone contained a little uric acid.

Table 1. Uric acid, uric acid dihydrate, and ammonium acid urate percentage occurrence in various collections of human urinary calculi. A strict comparison is not possible because of divergence of techniques and methods of presentation of data. In some cases, figures given in original papers have been weighted if the stone is reported as "pure." V, bladder or urethra; V+, mostly V; R, kidney or ureter; *a*, uric acid; *b*, uric acid dihydrate; *c*, ammonium acid urate.

Ref.	Place	Period	No. of stones	Ages (yr)	Site	Percentages in stones		
						a	*b*	*c*
(*12*)	Britain (Norwich)	1772–1828	663	$292<14$ $161>50$	V	..........78..............		
(*13*)	Britain	Before 1842	39	<21	V+	....12......		32
			41	>20	V+	....62......		0.2
			649	All	V+	....43......		18
(*14*)	India	1843–1871	83	<21	V+	....15......		22
			65	>20	V+	....29......		3
			148	All	V+	....22......		14
(*15*)	Britain	1843–1871	208	All	V+	....37......		12
(*16*)	Britain (Norwich)	1773–1909	51	<21	V	18	1	27
			33	>20	V	59	3	11
			84	0–75	V	35	1	21
(*17*)	China (Canton)	1861–1919	3371	43% <20	V	..........78..............		
			121		R			
(*18*)	Lebanon (Beirut)	1880–1907	288	<21	V	..........54..............		
			144	>20	V	..........59..............		
(*19*)	Thailand	1960–1962	58	<21	V	4	0.4	49
			18	>20	V	2	1	7
			65	17–68	R	6	0	2
(*20*)	Thailand	1963	200	Children	V	....11......		42
(*5*)	Turkey	1965	23	2–15	V	5	0	42
			53	2–14	R	1	0	34
(*21*)	Indonesia	?	40	?	V?	2	0	15
(*8*)	Denmark	1941	111	?	?	.....7......		0
(*22*)	U.S.	1949	1000	?	R?	.....5......		0
(*23*)	U.S.	1948–1961	24000	?	R?	....6–10....		0
(*2*)	Sweden	1955	140	?	V	....17......		5
			460	?	R	.....2.5		0.2
(*24*)	S. Korea	1954–1958	88	All	V,R	.....3......		17
(*25*)	Britain (Norwich)	1932–1940	56	3–67	V	7.5	3	2.5
		1941–1961			V,R			
(*26*)	Britain	1962	250	?	?	.....1.4		1.2
(*6*)	U.S.	1964	880	?	V,R	9	2	0
(*27*)	Australia	1965	73	20–50	R	.....1.4		0

Parsons (*6*) distinguished between uric acid and hydrated uric acid (which he called the monohydrate but has since confirmed by correspondence to be the dihydrate). Out of 880 stones from the Detroit area he found 61 pure uric acid, 14 pure hydrate, 13 mixed anhydrous and hydrated uric acids, and 17 anhydrous mixed with other constituents.

Table 2. Particulars of bladder stones found, by x-ray diffraction techniques, to contain uric acid dihydrate (see also *6*). Symbols used: *A*, uric acid; *A*2, uric acid dihydrate; *B*, ammonium acid urate; *C*1, calcium oxalate monohydrate; *C*2, calcium oxalate dihydrate; *G*, magnesium hydrogen phosphate trihydrate. The more abundant constituent is given first; parentheses indicate a minor constituent or trace; ? means doubtful or not known.

Year	Sex	Age (yr)	Composition of stone		
			Nucleus	Intermediate layers	Surface
			Norwich Museum, England		
1778	M	57	*A*, *C*1	*A*, *A*2	*A*1, *A*2 + (?)
1790	M	55	*A*2, *A*	*A*	*A*
1797	M	49	*A*, *A*2	*A*, *A*2	*G*
1877	M	12	*A*	*A*2	*C*1, *B*
			Norwich, England		
1932	M	64	*A*, *A*2	*A*, *A*2	?
1952	M	?	.........*A*, *A*2.......................		
1957	M	?	.........*A*, *A*2.......................		
?	?	?	*A*, *A*2	*A*, *A*2	*A*
			Ubol Hospital, Thailand		
1960	M	5	*B*, *C*1	*A*, *A*2, (*C*1,*C*2, *B*)	*A*, *A*2, *C*2
	M	46	*C*1	*C*2, *C*1, *A*2	*A*1, *A*2, (*C*2, *C*1)
			Turkey		
1964	M	?	*B*, *C*1, *C*2	*B*	*A*2, (*A* + ?)
	M	?	*B*	*C*1	*C*1, *C*2, (*A*2)