studies in which this subject is considered. Other agents besides minerals are involved in cell-wall differentiation. Jacobs (*10*), for example, has recently concluded that auxin is a limiting factor in the differentiation of xylem cells. Our evidence suggests that boron is one morphogenetic agent affecting the differentiation of cell walls. How this action may be mediated by boron is not understood. A close involvement of boron in cell-wall differentiation, however, is suggested by the fact that it very likely complexes with a number of polyhydroxy compounds in the plant, such as various sugars and pectic materials (*11*), which become part of the cell-wall substance.

Intensive studies of the cell walls in relation to boron nutrition show that the normal pattern of cell-wall differentiation is profoundly changed by boron deficiency. This fact and the relationship of boron to carbohydrate metabolism implicate boron as an agent in the morphogenesis of plant cell walls (*12*).

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Amino Acids in Fossil Human Bone

In a recent investigation of the chemical constituents of fossil human bone conducted in our laboratory, it was observed (*1, 2*) that bones of great archeological age may contain appreciable quantities of organic nitrogen. The significance of these findings for dating prehistoric bone has been discussed elsewhere (*2, 3*). It is highly probable that the source of this nitrogen is the original proteins, as suggested by Abelson (*4*). If so, a question of interest is: How many of the constituent amino acids are able to retain their chemical individuality under the conditions attending archeological preservation.

Table 1. Dates of fossil bone samples.

Designation	State and culture period	Date before the present by C^{14} analysis or tree-ring count (yr)
UK3	Kentucky, Archaic	4900–5300
UK25	Kentucky, Adena	1170–1510
S76	New Mexico, White Mound	1175
AP692	New York, Frontenac	4370–5385
8450-1	California, Middle	1880

Each bone was first completely hydrolyzed by hydrochloric acid. Then aliquots of the hydrolyzate were analyzed by two-dimensional paper chromatography. This made it possible to identify the presence of traces of amino acids. As a control, we first examined fresh human femurs secured from autopsy and established the presence of the following amino acids: glycine, alanine, serine, valine, leucine, isoleucine, phenylalanine, tyrosine, cysteic acid, proline, hydroxyproline, aspartic acid, glutamic acid, histidine, arginine, lysine and methionine-sulfoxide. This list agrees substantially with that published by Eastoe (*5*) for fresh bone.

We next investigated a series of 20 fossil human and three fossil animal bones, representing a wide time span from relatively recent to archeologically very old. In bones exposed to burial for comparatively short periods, most of or all the amino acids found in fresh bone are detectable in nearly normal amounts. Some of the samples falling within this classification are shown in Table 1.

In bones the age of which appears to be definitely greater than those shown in the table, the constituent amino acids begin to disappear. We have as yet not developed the quantitative analysis to the point where it is possible to set forth the details of an orderly progression of depletion or retention. Nevertheless, certain amino acids evidently persist in all but the very oldest specimens. Thus, sample 6075 (site FRe-48, California, very ancient) contained only aspartic acid. A human bone, early post-Pleistocene from site LAn-172, California, contained aspartic acid, glycine, and glutamic acid. A mammoth bone from Melbourne, Fla. (site Bre-44, very ancient) and a human bone from site SJo-142 (Early culture period, central California) both contained aspartic acid, glycine, and glutamic acid together with a few other amino acids which differed between the two samples. Finally, a human bone and a horse bone from Melbourne, Fla. (site Bre-44) both gave tests showing no amino acids whatever.

The preliminary results reported here therefore suggest the conclusion that decomposition of protein in buried bones proceeds extremely slowly over many thousands of years but tends to release in the process certain amino acids while retaining certain others with great tenacity (*6*).

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Behavior of Light- and Dark-Reared Rats on a Visual Cliff

From the 18th century to the present, the empiricist and the nativist theories of depth perception have been vigorously debated. One experiment aimed at resolving the dispute is Lashley and Russell's (*1*), in which rats reared in darkness jumped to a platform from a stand placed at a variable distance from it. The force of the jump was found to be graded in accordance with the distance of the platform. This is evidence for nativism. But, since the tests with graduated distances were not given until the rats' third day in the light, and after pretraining, the conclusion was not indubitable. Confirmation by another technique is desirable and has been provided in the experiment described in this report (*2*).

A technique of testing for visual depth perception which involves no pretraining at all—the "visual cliff"—was developed. It is based on the assumption that, given a choice, an animal will avoid descending over a vertical edge to a surface which appears to be far away (*3*). The apparatus (Fig. 1) was constructed of two thicknesses of glass (24 in. by 32 in.), parallel to the floor and held by metal supports 53 in. above it. A board (4 in. wide, 24 in. long, and 3 in. high) extended across the glass, dividing it into two equal fields. On one side (the "near" side), patterned wallpaper was inserted between the two sheets of glass. Through

the clear glass of the other side (the "far" side) the same pattern was visible on the floor and also on the walls below the glass surface.

Optically speaking, the edge on one side of the board dropped away for a distance of 53 in. (making the simulated cliff), while on the other side the edge dropped away for only 3 in. Thus, two visual fields existed, both filled with patterned wallpaper, but the pattern of the "far" field was optically much smaller and denser than that of the other and elicited more motion parallax. (More binocular parallax was also possible at one edge than at the other, but the rat is probably insensitive to this cue.) The fields were matched for reflected luminous intensity. The physical space, as distinguished from the optical space, was identical on both sides, since a glass surface was present at a distance of 3 in. The only difference between the two fields, therefore, was a difference in optical stimulation. Other possible cues for safe descent (tactual, olfactory, auditory echolocation, air currents, or temperature differentials) were equalized by the glass.

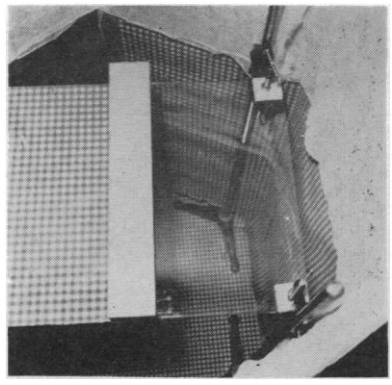
In addition to the experimental condition described here, a control condition was included, in order to check on the presence of any unknown factors that would make for a preference for one side. A piece of wallpaper was inserted between the glass on both sides (Fig. 2); otherwise, the apparatus was identical to that for the experimental condition. If controls are adequate, animals should show no preference for either side in this case.

Subjects for the experimental condition were 19 dark-reared, hooded rats, 90 days old, and 29 light-reared litter mates. Twenty minutes after coming into the light, the dark-reared rats were placed on the apparatus. An animal was placed on the center board in a box, to avoid any handling bias. It was then observed for 5 minutes. Results are summarized in Table 1. The percentage of animals that descended on the near side was not significantly different for light- and dark-reared rats. Of the light-reared rats, 23 descended on the near side, three descended on the far side, and three remained on the board for all 5 minutes. Of the dark-reared rats, 14 descended on the near side, three descended on the far side, and two remained on the board.

But a comparison of descent behavior of the experimental animals with the controls, for whom the visual surface was near on both sides, showed a difference. The control group, all light-reared litter mates of the experimental group, showed no preference in descending from the board; five went to each side. This group differs significantly from the experimental group ($p < 0.02$).

Even more interesting is a comparison of the exploratory behavior of the animals. The light-reared and dark-reared rats of the experimental group again behaved similarly; most of them stayed on the side of the center board that they had first chosen. Of the 43 experimental animals that descended from the board, only one crossed to the other side. But the control animals explored back and forth, often crossing the board to the other side several times. The difference in crossing behavior between experimental and control groups is highly significant ($p < 0.001$). The percentage of time spent on the two sides confirms the other measurements. Both experimental groups spent more than twice as much time on the side with the near optical pattern as on the side with the far optical pattern, while the control animals reversed this trend.

These results suggest two conclusions. First, hooded rats, 90 days of age, do discriminate visual depth or distance. They avoid a visual cliff as compared with a short visual drop-off, and this preference is eliminated when the visual cliff is eliminated. Second, such discrimination seems to be independent of previous visual experience, since dark-reared adult animals behaved like their light-reared litter mates only 20 minutes after being exposed to the light.



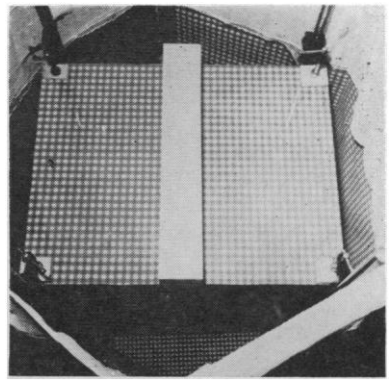


Fig. 1 (left). Apparatus for the experimental condition. The larger-checked field is the "near" side, optically; the clear glass field is the "far" or "cliff" side. Fig. 2 (right). Apparatus for the control condition.

Table 1. Comparison of light- and dark-reared animals on a visual cliff (experimental group) and comparison of both with a no-cliff control group.

	Experimental group		Control group
	Light-reared ($N = 29$)	Dark-reared ($N = 19$)	Light-reared ($N = 10$)
Percentage descending on "near" side	88.5	82.4	50.0
Mean No. crossings	0.00	0.06	1.70
Percentage of time			
On "near"	76.0	57.9	24.1
On "far"*	10.0	16.9	61.5
On board	14.0	25.2	14.4

* The control group had no optically "far" side. Reference is to the same physical side that was "far" for the experimental group.

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3. The work of K. T. Waugh [*J. Comp. Neurol.* 20, 549 (1910)] and J. T. Russell [*J. Genet. Psychol.* 40, 136 (1932)] makes this assumption seem plausible. Latency of jumping or "disinclination to jump" apparently increased as distance increased.

1 May 1957