phase, beginning only after 3 days shows the reverse: the older memories are more susceptible to effects of the drug. The memory process may have two biochemical phases which are differentially sensitive to disruption.

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Extraterrestrial Dust as a Source of Atmospheric Argon

Tilles (*1*) points out that solar-wind bombardment may emplace small amounts of noble gases on the surfaces of extraterrestrial dust particles. Heating of the particles during entry into the earth's atmosphere would release the volatiles. Tilles suggests, on the basis of an estimate of the influx of black spherules to the earth (*2*), that as much as 20 percent of the argon-36 and argon-38 in the atmosphere could be contributed by this mechanism. The strength of this source thus depends directly on the influx of extraterrestrial material to the earth.

The influx rate assumed by Tilles (Table 1) was based on black spherules collected from snows of the Greenland ice cap. Probably not all the spherules recovered from polar snows are of extraterrestrial origin. Giovinetto and Schmidt (*3*) found black spherules to be concentrated in snow layers deposited at the South Pole during years when paroxysmal volcanic eruptions took place. The spherule concentration was especially great in the snow layer representing 1883, when the famous eruption of Krakatoa occurred. The earlier suggestion by Schmidt (*4*) that volcanic dust could not be transported great distances to the polar regions is not supported by the newer data. Occurrence of volcanic dust in polar snows is consistent with the work of Flowers and Viebrock (*5*), who attributed a decrease in solar radiation at the South Pole to dust carried to Antarctica from the eruption of Mount Agung in Bali. It therefore appears likely that estimates of "cosmic" spherule flux, based on particle collections from either Greenland or Antarctic snows, are too great by some unknown amount. Even if it is assumed that all the spherules collected from polar snows are of extraterrestrial origin, the Greenland value is not characteristic of the spherule influx at other polar sites. It is about an order of magnitude greater than the mean influx rate determined for black spherules occurring in the Antarctic ice cap (Table 1). If the Antarctic influx value is used in the equations, only about 2 percent of atmospheric argon-36 and -38 could be accounted for by the mechanism proposed by Tilles.

Spherules of probable meteoritic composition were recovered from deep-sea sediments by Pettersson and Fredriksson (*6*). Assuming for the moment that these spherules entered the atmosphere as discrete particles and thus satisfied the criteria of Tilles' mechanism, the influx rate yields a negligible amount of argon-36 and argon-38 (Table 1). However, it is more likely that the value derived from Pettersson and Fredriksson's influx rate represents an upper limit to the amount of noble gases contributed by the spherules, which appear to be droplets resulting from atmospheric ablation of larger meteorites.

While the influx data for probable extraterrestrial spherules indicate only a negligible contribution of noble gases, other varieties of extraterrestrial dust may be present in sufficient quantity to fulfill the requirements of Tilles' ingenious mechanism. Investigation of this possibility should be provided for in future collections of dust particles of extraterrestrial origin.

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Table 1. Comparison of amounts of argon introduced into the atmosphere under different assumed rates of influx of extraterrestrial spherules. The amount of argon-36 and argon-38 is based on the calculation presented by Tilles. The only parameter changed is the influx of extraterrestrial spherules.

Influx rate of extraterrestrial dust (g cm^{-2} $year^{-1}$)	Volume of argon per square centimeter over Earth's surface (cm^3)	Percentage of total Ar^{36} and Ar^{38} due to extraterrestrial dust
	Greenland snow (2)	
2×10^{-7}	4.6	~20.0
	Antarctic snow (4)	
2×10^{-8}	0.5	~2.0
	Deep-sea sediments (6)	
1×10^{-9}	0.03	~0.002

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Old Faithful

I find myself concerned with J. S. Rinehart's hypothesis [*Science* **150**, 494 (1965)] of a dual cavity to explain the bimodal nature of Old Faithful's period. It would seem wise to search for a simpler model first, and indeed the data seem to suggest one. If, in the previous eruption, the cavity was incompletely emptied, then one might expect new activity to build up more quickly and the period to be briefer. The evidence that during short periods seismic activity starts immediately, whereas during long periods there is a 20- to 30-minute quiet, supports this alternative hypothesis. It might be tested by comparing the duration, or better the volume, of eruption with the time interval preceding the next eruption.

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28 October 1965

In actuality the relation between the play of water and the time between eruptions is just opposite to that which Geis suggests. A short time of play heralds a long interval, whereas a long play heralds a short interval. The National Park Service personnel depend on this relationship in informing visitors when the next eruption will occur.

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Perception by Locusts of Rotated Patterns

In 1962, using as visual stimulus a symmetrical pattern of black and white stripes moved across a fixed window in an opaque screen (*1*), we concluded that threshold responses could be detected in the nerve cord of the locust when the angle subtended by adjacent stripes was as low as 0.3 deg. This finding has since been confirmed by Palka (*2*), who has, however, offered an alternative explanation of the result, in which what is relevant is not the angular separation of adjacent stripes of the pattern but certain effects occurring at the edges of the window. Palka claims that inclination of the edges of the window to the stripes greatly reduces the response. He further suggests that a resolution of 0.3 deg transgresses the Rayleigh limit, taking into account the geometry and dimensions of the single ommatidium. With this we agree, but, according to the diffraction theory we propose, the images found deep in the eye are related to a much larger entrance pupil than that of a single ommatidium; it is these images that we suggest give rise to the high degree of resolution we observe.

A similar criticism of our interpretation is offered by Barlow (*3*), who has further shown that anomalous values (two to four times the normal) can be obtained for resolution of the human eye when a striped pattern is moved behind a fixed window. The movement of such a pattern was detected by the human eye in Barlow's experiments as a flickering at the edges where the pattern met the window, even when the central part of the pattern was not resolved.

It was clearly important that we should repeat our experiments with a stimulus system in which edge effects were as far as possible eliminated, to see whether our original result could then be reproduced. A large wheel pattern consisting of radial black stripes on a white ground was made, with a careful attempt to maintain evenness of stripe width and separation. This was photographically reduced by a factor of about four, and the print so obtained was mounted on a rotating carrier behind a circular aperture 7 cm in diameter in a large black screen. The central area of the pattern was eclipsed by a plain disc alternatively white or black, leaving about 1.5 cm of each stripe visible at the periphery. Care was taken to see that the pattern rotated concentrically with the aperture and that the illumination was uniform. Stimuli, presented at 10-second intervals to avoid fatigue, consisted of rapid rotations through an angle of about 45 deg, alternately clockwise and anticlockwise as viewed by the insect. Movements were executed manually, and velocity was not precisely controlled. Adopting the 50-percent response level as threshold criterion (spike responses of the nerve cord), we repeatedly obtained resolutions down to 0.3 deg, using radial patterns with stripe separation 3.6 mm at the edge. The diameter of the whole wheel pattern then subtended an angle of about 6 deg at the eye.

An interesting feature of the experiments was that all insects examined were able to distinguish clockwise from anticlockwise rotations. Of 11 eyes tested, where the responses to 20 stimuli, alternately clockwise and anticlockwise, were recorded, 7 showed lower threshold for clockwise and 4 for anticlockwise rotation. The two eyes of any one insect behaved similarly, rotational preference being a feature of the individual insect. The difference in scores for clockwise and anticlockwise movements only became apparent when the pattern was at a distance from the eye approaching the resolution limit, and was often very marked in this condition. There could be complete failure to respond to one direction of rotation while a high score was still obtained with the opposite rotation.

A further observation of some importance was that, when the central black area was replaced by white, there was a marked inhibition of the responses, in such a way that low figures for resolution were obtained, not better than 1 deg. On the other hand, when the black screen surrounding the pattern aperture was covered with white paper, the response was not only not inhibited but was slightly increased.

It seems clear that, with a wheel pattern, resolutions of the same order as those reported earlier for linear patterns enclosed by a window can be obtained, and that edge effects appear to contribute little to the responses recorded. As an additional check on this point we have intentionally introduced a window by obscuring one half of the wheel-pattern aperture—upper, lower, left, or right—and have tested the responses before and after this maneuver. We have found no significant change in score.

Tests have been made using the same rotated pattern on human eyes. Five volunteers were asked to detect the movement of the pattern at increasing distances. The limiting values so found ranged from 1.1 to 1.6 minutes. Thus so far there has been no suggestion of the anomalously high resolution which Barlow found using the horizontal window.

We cannot readily explain the effects of inclining the pattern within the window which are reported by Palka. We would, however, draw attention to our earlier work (*1*), in which linear patterns were moved at various angles with respect to the horizontal meridian of the eye, though still at normal alignment within the window. We found that threshold varied widely with angle of presentation, but no regular axes of maximum and minimum could be established. Such axes, spaced at 60-deg intervals, are predicted by the diffraction theory (*1*) for a hexagonal array of facets, and can readily be seen in eye slices examined under the microscope when the object pattern is rotated. Again the wheel pattern has the advantage of eliminating the possibility of inadvertently presenting linear stimulus movements along axes of differing resolution.

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