

osmotic pressure increases during stress appears to be extremely fast, the possible utility of this phenomenon in tracing emotional states is intriguing. But an understanding of the characteristics of stimuli effective in producing this phenomenon, as well as the exact nature of the fluid-solids shifts underlying the increase in osmotic pressure, must await further detailed investigations.

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References and Notes

1. P. S. Siegel and H. S. Siegel, *J. Exp. Psychol.* **42**, 12 (1949).
2. According to Hull's hypothesis, the strength of a response, measured in terms of frequency or probability of occurrence, is a function of habit strength, H, and the general drive, D, which activates H. The construct D includes not only the strength provided by the relevant need state but also that contributed by irrelevant need states, such as anxiety. Increasing an irrelevant need can increase the response strength approximately as effectively as increasing the relevant need. See C. L. Hull, *Principles of Behavior* (Appleton, New

York, 1943); K. W. Spence, *Amer. Psychol.* **13**, 131 (1958).

3. A. Amsel and I. Maltzman, *J. Exp. Psychol.* **40**, 563 (1950).
4. P. S. Siegel and J. J. Brantley, *ibid.* **42**, 304 (1951).
5. E. Deaux, J. W. Kakolewski, E. Sato, *Physiol. Behav.*, in press.
6. J. W. Kakolewski and E. Deaux, *Amer. J. Physiol.* **218**, 590 (1970).
7. The tables for the handled condition include two subjects that ate after first drinking in the second hour; four of the subjects that ate following rotation did so after drinking first. These effects were not considered in the statistical analysis, which was McNemar's test for differences in nonindependent proportions. See Q. McNemar, *Psychological Statistics* (Wiley, New York, ed. 3, 1962), pp. 52-54.
8. M. R. A. Chance and A. P. Mead [*Behaviour* **8**, 174 (1955)] reported a significant increase in latency to the onset of eating, following handling, in 24-hour deprived rats.
9. J. W. Kakolewski and E. Deaux, *Commun. Behav. Biol.*, in press.
10. The chi-square test used assumes a probability of 0.5 that any one subject will begin (or, conversely, not begin) to eat. The chi-square was 7.34 with 1 degree of freedom.
11. Analysis of variance of the data showed $F = 8.85$, d.f. = 1/28, for the handling condition; for groups and days, F was less than 1.0 in both cases.
12. Serum glucose levels were also determined for the animals in this experiment, but no significant difference was found between the groups ($F < 1.0$, d.f. = 1/18).
13. This research was supported in part by National Institute of Mental Health grant M-4529, research grant NGL 36-005 from NASA, and a College Science Improvement grant from NSF.

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Megalithic Rings

The megalithic structures of the British Isles and of western Europe continue to attract considerable attention, in part because of their monumental scale and evident regularity of construction and in part because of man's natural curiosity about the builders. Cowan (1) has speculated on a grand plan underlying and unifying the design of the rings, at least those of the British Isles. In my opinion his arguments have serious weaknesses.

Suppose excavators were to find a board long buried, and suppose careful cleaning and scrutiny revealed it to be covered by a regular pattern, too regular to have been accidental. A clever scholar might suggest that the board had been used for a game, and he might devise a game to be played on the board, one that might prove amusing, even engrossing. There is no harm in all this, provided the players do not become convinced that their game is the one originally played on the board. Some skeptic might even suggest that the board is not a game board after all, but had some other function.

The megalithic rings are a magnificent game board. Many of the rings have been accurately surveyed, and the

results are readily accessible (2). The game is to fit simple geometric figures to the plans, and Cowan did so. If he had stopped there, the game would have been well concluded, and playing it would have been a pleasant recreation, as Cowan suggests at the end of his article. But he chose to speculate on the psychology and the scientific abilities of megalithic man, and this seems to me unjustifiable on the basis of present evidence.

Cowan approximated the rings by simple figures composed of arcs of a circle, tangent at junction points. By just such a method, every smooth curve can be approximated to any desired degree of approximation. Scrutiny of the plans of the rings given in Thom's book shows that agreement of Thom's proposed approximations with the actual positions of the stones is often very rough. To judge from the evident irregularity in placement of the stones, Cowan's approximations cannot be much better.

Why arcs of a circle? Granted, they are quite easy to lay out with rope and stake. But Cowan justifies his use of them by going back two millennia, to the Platonists. He states, "To a ge-

ometer, probably few things are more intuitively satisfying and esthetically pleasing than an absolutely perfect circle drawn by rotating a radius around a point" (3). This esthetic-mystic reasoning led Western cosmology into the quagmire of the epicyclic theory of planetary motion, involving circle upon circle, level upon level. No geometer has believed in the perfection of the circle since Kepler and Newton laid the epicyclic theory to rest. But if the history of science gives any clue to future developments, it is that we may expect epicyclic corrections to Cowan's descriptions. In fact, the first such correction appears in Cowan's article: the cardioid is an epicycloid.

Thom gave involved statistical evidence to support his claim that the rings were laid out in integral multiples of a unit he calls the "megalithic yard." According to Cowan, Thom convincingly argues that the builders were "obsessed with a concern for perfection—so much so that all their measures were laid out in integral units." (In fact, Thom's work contains many instances of adjustment of his measurements to preserve commensurability.) Yet we have no record from the megalithic builders of their intents or motives, no blueprints, no record of a single calculation to justify the assumption of any such compelling psychological drive.

Cowan's article is full of unsupported conjectures about the motivations and psychology of the megalithic builders. What are we to think of a phrase such as, "If the builders were an inquisitive lot, *as no doubt they were*" (italics added)? Or of this, concerning the circle: "undoubtedly discovery of the irrational [*sic*] ratio between the diameter and the circumference was frustrating to the megalithic geometers." The word *irrational* is obviously a misapprehension (perhaps a misnomer for "nonintegral"); if, as claimed, the megalithic geometers found this ratio "irrational," this would have been a mathematical achievement not equaled by Western civilization for another three millennia, until Lambert, in 1761, proved the irrationality of π .

The discovery of Pythagorean triangles can be a very satisfying game. The 3,4,5, right triangle, simplest of all, has fascinated many Egyptologists who were convinced that it could have been, and probably was, used by Egyptian surveyors. They have not

been shaken in this opinion by the lack of a single example of such a rope device in the wealth of well-preserved Egyptian artifacts; by its absence from any tomb paintings or other paintings; and by the failure of any extant Egyptian mathematical writings to describe such a device or even to intimate its existence. Did the megalithic men leave any direct evidence that they understood Pythagorean triangles? No.

Determining the mathematical capabilities of the megalithic builders by examination of the stone rings is comparable to deciphering an unknown language from ancient inscriptions. There is no evidence that the mathematics of the megalithic builders is similar to the mathematics of the Greek tradition which still forms the basis of our mathematical training. Without a mathematical Rosetta stone, all attempts at understanding the megalithic mathematics are merely conjectural. Discussing decipherment of unknown languages, Johannes Friedrich gives an incisive warning (4): "I must state once again the fact, self-evident and trite as it may be, that the decipherment of any unknown script or language presupposes the availability of some clue or reference; *nothing can be deciphered out of nothing*. In those cases where one has absolutely no possibility available to link the unknown to something known, the amateur can give free rein to his imagination, but no real or lasting result can be accomplished."

I agree with Cowan that "perhaps much remains hidden in these remarkable sites." It is to be hoped that archeological investigation will reveal real evidence of the motivations and methods of the builders. Until such evidence is uncovered, I will continue to look upon such exercises as Cowan's as amusing games, and to view with admiration and awe the megalithic men who conceived and built the sites for their own personal, and still unknown, reasons.

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References and Notes

1. T. M. Cowan, *Science* **168**, 321 (1970).
2. See, for example, A. Thom, *Megalithic Sites in Britain* (Oxford, London, 1967).
3. I am a practicing geometer, and I find quite a few mathematical things more intuitively satisfying.
4. J. Friedrich, *Extinct Languages* (Philosophical Library, New York, 1967), p. 151.

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Fungal Archimedean Spirals

Bourret *et al.* (1) presented examples of beautifully regular spiral and concentric patterns of zonation in plate cultures of two fungi. Especially interesting is their figure 2, which shows that the space between bands of spores is constant even when a double spiral arising from two spores is present. As Bourret *et al.* point out, in double spirals every other band originates from one of the two mycelia and the spacing between these alternate bands is twice that between bands of a spiral originating from a single spore. If the banding is an expression of an endogenous rhythm, then in the case of double spirals, the period of this rhythm is exactly twice that in single spirals. This seems extremely unlikely. The constancy of the spacing between bands points to their origin in changes in the medium resulting from mycelial metabolism.

Banding patterns and concentric rings are known in bacterial cultures and are considered to be the result of progressive exhaustion of single components in the medium and chemotaxis in the chemical gradient thus produced (2). A similar explanation, that invokes changes in concentration in the medium which affect sporulation might

account for the banding patterns of *Nectria cinnabarina* and *Penicillium diversum*.

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References

1. J. A. Bourret, R. G. Lincoln, B. H. Carpenter, *Science* **166**, 763 (1969).
2. J. Adler, *ibid.* **153**, 708 (1966).

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The colonies that produced double spirals as described in our report were not composed of "two mycelia," but of one mycelium which arose from a single spore, not "two spores." Thus, in the case of the colony producing a double spiral, all the bands are produced by one mycelium. When viewed along a radial transect, the period of the rhythm is the same as in the mycelium that manifests the rhythm as a single spiral. Whether this or any other biological rhythm is entirely endogenous has not been resolved, but the experimental evidence to date seems to justify our use of the term.

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Somatic Cell Mating in Frogs

Volpe and Earley (1) have proposed that hybrid cells can be demonstrated in bone marrow cultures of diploid-triploid parabiogenic chimeric frogs. Their evidence is the observation of two pentaploid metaphases in cultures from one of the 22 individuals examined; the analysis of one of these is presented as figure 2 in their report and is here reproduced (Fig. 1). If a curved line of regular contour is drawn as shown in the figure, it divides the chromosomes into two groups: A ($2n = 26$) and B ($3n = 39$). These two chromosome groups are euploid sets. The group of origin of the homologs numbered 1 through 5 in the photokaryotype may be determined from the intact spread: (1) AABBB, (2) BBBAA, (3) BBABA, (4) BBAAB, (5) BBBAA. The order given is that shown in the lower part of the figure. The five examples of chromosome 10, which bears the secondary constriction, have the following origins:

AABBB. The small chromosomes 6 to 9 and 11 to 13 have not been analyzed in this way, but of these 35 chromosomes, 21 are found in group B and 14 in group A.

It is therefore reasonable to conclude that groups A and B are diploid and triploid metaphases that lie close enough together on the slide to produce an artifact. Such instances of interference can usually be recognized by differences in staining or degree of compaction between chromosomes of the two groups, but in this case the two groups are remarkably similar. One reason for concluding that a chromosome spread is a hybrid metaphase is the random position within it of chromosomes of differing origin. Since this "pentaploid" is so clearly an artifact, the claim for cell hybridization, which is the basis of the report by Volpe and Earley (1), is not supported by the cytological evidence they present. It would be of great inter-