mental output: under a variety of reinforcement schedules, enormous numbers of unnecessary responses are made (*8*). Second, even when rewards are freely presented without regard to specific responses, the rewarded animal nevertheless acts as if it were producing the reward: behavior is vigorous, consistent, and stereotyped—that is, superstitious (*9*). These and the present findings suggest that animals often emit instrumental responses which reduce no biological need and abolish no threat. To make an animal press a lever for food, one need not first deprive or otherwise motivate the animal. The act of producing food can serve as its own motivation and, therefore, as its own reward.

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References and Notes

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3. Animals will work for some types of visual and auditory stimulation; see G. B. Kish, in *Operant Behavior: Areas of Research and Application*, W. K. Honig, Ed. (Appleton-Century-Crofts, New York, 1966), pp. 109–159.
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Planetary Formation and Lunar Material

The indications (*1*) that "igneous" lunar rocks are old, perhaps as old as the meteorites, may lead to the suggestion that the moon experienced a period of intense volcanic activity early in its history. I point out here that there is no need for volcanoes to have occurred *in situ* on the moon. Considerations of angular momentum (*2*) show that planetary material probably separated from the sun when the radius of the latter was considerably greater than its present value. Current work on stellar structure requires that the effective surface temperature of the solar condensation be substantially constant at 3500° to 4000°K during this phase, independent of radius. Hence, for comparatively large radii the luminosity would have been very much greater than the present-day value, so that primitive planetary material could well have been considerably hotter than would be estimated for material at corresponding distances from the present-day sun.

Quantitative consideration of the angular momentum problem suggests that the planetary material separated from the sun when the radius was $\sim 2 \times 10^{12}$ cm. Such material driven out to the terrestrial distance of $\sim 1.5 \times 10^{13}$ cm would be expected to experience temperatures of $\sim 3500 \times (7.5)^{-\frac{1}{2}}$°K, which is not much different from the temperature in volcanoes. Thermochemical details relating to this situation have been reported elsewhere (*3*). Here I simply remark that melting and chemical segregation could have taken place within the primitive planetary material, even though this hot phase was short-lived, $\sim 10^4$ to 10^5 years. It will be of great interest to see if the recently acquired samples of lunar material establish the existence of such a hot phase, and, if so, to discover if any features of terrestrial geochemistry, which have hitherto been attributed to igneous activities on the earth itself, really belong to the initial primitive phase of the solar system.

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2 October 1969

Pyroxene Gabbro (Anorthosite Association): Similarity to Surveyor V Lunar Analysis

The data from the alpha-scattering experiment of Surveyor V in Mare Tranquillitatis (*1*) resemble data from average oceanic basalts with, however, several major exceptions, principally Ti. Turkevich *et al.* (*1*) concluded that no common earth material provided a match for these revised lunar data and that perhaps special geochemical processes were required to produce the lunar material.

One terrestrial rock type, however, does bear a striking resemblance to these refined data. Pyroxene gabbros, late differentiates of major anorthosite masses, are almost always titaniferous, containing major amounts of sphene or ilmenite, or both. Two typical analyses from the Adirondack Mountains (Table 1) are close to the Surveyor data for all oxides except Na_2O. The observed plagioclase compositions in these gabbros range from An 42 to An 50 (*2*). Better agreement for Na_2O results if one simply postulates that the lunar gabbros bear a more anorthite-rich plagioclase. If we assume an An content of about 85 for the lunar sample, then the analysis can be recomputed (Table 2) with closer agreement.

Thus, it appears that a better candi-

Table 1. Oxide compositions of lunar surface (*1*) and of two pyroxene gabbros from anorthosite masses in Adirondack Mountains (*2*). Gabbro 1 is pyroxene gabbro facies of gabbroic anorthosite from near Brown Pt., N.Y. Gabbro 2 is sphene gabbro pegmatite from Wilmington, N.Y. Water and sulfur not included here for either gabbro.

Oxide (% by weight)	Lunar surface	Gabbro 1	Gabbro 2
SiO_2	46.4	45.2	44.3
TiO_2	7.6	6.9	9.6
Al_2O_3	14.1	11.8	13.2
FeO	12.1	15.5*	6.6†
MnO		0.2	0.1
MgO	4.4	6.4	2.0
CaO	14.5	10.2	18.4
Na_2O	0.6	2.1	2.8
K_2O		0.5	0.4
P_2O_5		.2	1.2
CO_2		.3	0.5
	100.0	99.3	99.1

* Contains 1.6 percent Fe_2O_3 recalculated to FeO. † Contains 1.4 percent Fe_2O_3 recalculated to FeO.