fit tightly. The butt of the electrode was permanently secured in a nylon sleeve threaded to fit the guide. The electrode could be advanced by turning the sleeve so that it screwed down the threads of the guide, and it could be fixed in position by tightening a set screw on the side of the sleeve. This system permitted recording from the same cell during repeated trials involving violent movement for periods of up to several hours. Two-thirds of the cells encountered were recorded before, during, and after at least one fighting trial, without signs of injury, pronounced changes in spike amplitude, or loss of electrical contact with the cell. After the electrode had been in place for several hours, however, cells could no longer be held; their spikes would diminish in amplitude or disappear whenever the cat moved and reappear again after it came to rest.

Because the technique of recording from single brain cells during free-moving, violent behavior is relatively unprecedented, particularly strict criteria were used for the acceptance of a response as being that of a single uninjured brain cell. All recordings were played back into an oscilloscope, and only responses with a waveform of constant shape, duration, and amplitude were accepted as coming from a single cell. Records of multiple units were discarded unless a single cell had a spike amplitude consistently greater than the highest background activity. Most spikes, including those of all cells which fired only or maximally during fighting, were initially negative; purely positive spikes were also accepted although the literature suggests that they may be axon recordings. Cells which changed irreversibly in baseline firing rate, which had spontaneous and sudden high-frequency discharges, or which had notches or changes in waveform were discarded as probably injured.

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Straight Lines on Semilog Paper

In his report concerning distribution of capillary blood flow through a homogeneous tissue (*1*), Hills proves that washout data which give a straight line on semilog paper can come from a system made up of two or more compartments in parallel only if the time constants of all the compartments are the same. My objection is that Hills wrongly attributes to me his straw-man premise that the time constants could vary and still yield a straight line. My work (*2*) has been devoted to cases where experimental results do *not* yield a straight line; I point out that although a curve on semilog paper can easily be "peeled" into two or three straight lines (each supposedly representing a compartment with its own time constant), the underlying system may actually be a large number of compartments with a whole frequency distribution of time constants.

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The objection raised is incidental to the main theme of my report (*1*) which shows that the overall response for the elimination of a tracer from a single tissue type cannot be linear if heterogeneous blood perfusion is the rate-limiting process.

My comment that "Van Liew . . . has indicated the need to consider whether any linear response obtained from a biological system is contributed by a continuum of exponential processes" was included to acknowledge his presumed recognition that there could be a continuous spectrum of responses within one or more compartments. The comment was carefully phrased to avoid discussion of a gross assumption in his report (*2*), which is essentially repeated in the above objection, and would appear to form the basis of this issue.

Van Liew's technique of "peeling" components from a semilog plot is feasible *only* if the overall response can be expressed as the sum of a number of exponential terms. However, this overall form can be obtained only from a system whose compartments give responses of such form when isolated. This can be seen from analysis by Laplace transforms, such as used by Segre (*3*) for a general biological system covering all feasible arrangements of compartments. Deviation from linearity cannot be accommodated in parallel models, and in compartments in series only if their isolated responses have imaginary components—not a practical case.

The vital issue therefore is whether there can be any frequent distribution of linear responses within one compartment, or of simple compartments in parallel, which can give an overall response that can be expressed as two or more exponential terms.

If we repeat the analysis given in my paper for Van Liew's suggestion of a two-component curve, then the frequency distribution would need to be

$$\int_0^1 \exp(-kt)dR \equiv A_1.\exp(-K_1t) + A_2.\exp(-K_2t) \quad (1)$$

where R is the fraction of the maximum possible change responding linearly with a time constant less than or equal to k; t represents time. K_1 and K_2 are the time constants of the two components postulated, and A_1 and A_2 are their respective amplitudes.

Taking successive derivatives with respect to time and putting $t = 0$

$$\int_0^1 dR = A_1 + A_2 = 1 \quad (2)$$

$$\int_0^1 kdR = A_1K_1 + A_2K_2 \quad (3)$$

$$\int_0^1 k^2dR = A_1K_1^2 + A_2K_2^2 \quad (4)$$

Now

$$\int_0^1 (k - K_1)(k - K_2)dR = \int_0^1 k^2dR - (K_1 + K_2).\int_0^1 kdR + K_1K_2.\int_0^1 dR = 0 \quad (5)$$

after substituting for the integrals according to Eqs. 2–4.

Since K_1 and K_2 must be real, k is real only if $(k - K_1)\ (k - K_2) \geqq 0$. This is compatible with Eq. 5 only if $(k - K_1)\ (k - K_2) = 0$, for which the only real solutions are $k = K_1$ or $k = K_2$ (but not both simultaneously nor any distribution); that is, all elements must have the same response time.

Thus there would appear to be no frequency distribution of linear processes whose overall response can be resolved into two exponential terms. A similar result can be obtained for three terms or more.

Hence Van Liew's prediction (*2*) of a multiexponential response from a continuum of linear processes would appear to be pure conjecture—particularly when such speculation is accompanied by no mathematics whatsoever.

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Implications of the Surveyor V Chemical Analysis

The interpretation of the alpha backscattering chemical analyses of the lunar surface given by Gault *et al.* (*1*) overlooked some important differences between the lunar and terrestrial material. In addition, the inferred chemical differentiation of the moon is not a necessary consequence of the observed chemical composition.

It is unfortunate that the alpha backscattering technique cannot resolve the heavy elements in more detail. Some additional information may be gained if we add to the observations two rather plausible assumptions: (i) those elements above P in atomic number consist primarily of Ca and Fe with minor amounts of K, Ti, and Ni (to make a comparison, I lump Ca plus K, and Ti, Fe, and Ni); and (ii) the atom ratio of Ca to Al on the lunar surface is similar to that in terrestrial basalts or in eucrites. Significant chemical differences between the terrestrial basalts and eucrites (*2*), in particular the high iron and low sodium content of the latter, are evident in the comparison given in Table 1. My assumptions regarding the lunar material require that the iron, nickel, and titanium content of the mare material is even higher than that of the eucrites. If the second assumption is not made, the calcium and potassium content inferred for lunar material must be increased if the iron content is reduced. Thus, either the Ca and K content or the Fe, Ti, and Ni content of lunar mare material is significantly greater than that of terrestrial basalts. Any significant reduction in the limit for the Na content given by Turkevich *et al.* (*3*) results in a ratio of Na to Si (for the lunar material) that is more like that observed in eucrites than in basalts.

The similarities of the eucrites and mare material support the suggestion (*4*) that these meteorites originate on the moon. If the origin of mare material is related to the origin of material with a similar chemical composition, the textures and chemical compositions of the eucrites rather than those of terrestrial basalts should be considered.

If the origin of mare material cannot be inferred as a priori consequence of its chemical composition, the wide-scale differentiation of the moon that is implied by Gault *et al.* (*1*) must rest on the presumed ultrabasic or peridotitic composition of the moon. Thus, an answer to one of the most interesting questions raised by planetary exploration, that is, whether or not there are major differences in the bulk chemical composition of planetary bodies, is assumed by Gault *et al.* (*1*) to arrive at the conclusion that the moon is probably differentiated.

The chemical fractionation processes that have operated during the formation of planetary bodies and meteorites may have resulted in planetary bodies and meteorites with varying chemical compositions (*5, 6*). Enrichment in Ca and Al is expected in any material enriched in iron for solid matter formed by condensation from a gaseous nebula with solar composition (*6*). The possibility that the entire moon, or a substantial fraction of it, is characterized by high contents of Al, Ca, and Fe should be considered before these chemical characteristics of surface materials are used to infer earthlike magmatic differentiation processes on the moon.

Table 1. Comparison of chemical elements in lunar mare material, oceanic tholeiites (abyssal basalts), and eucritic meteorites.

Elements	Lunar mare material	Oceanic tholeiite (*8*)	Eucrite Pasamonte (*7*)
O	56 ± 5	60.4	59.8
Na	<2	1.9	0.23
Mg	3 ± 3	3.9	3.7
Al	6.5 ± 2	7.4	6.3
Si	18.5 ± 3	18.2	18.5
$>$P	13 ± 3		
FeCoNi	>3		
(Ca + K)*	3.9	4.6	4.2
(Fe + Ti + Ni)*	9.1	3.0	6.4

* Assume that the ratio of Ca to Al is the same as in basalts and that $>$P is predominantly Fe and Ca.

The chemical analysis resulting from the analysis of alpha backscattering also suggests an important geophysical result. If the material analyzed is representative of the lunar surface, the density of compacted material with the composition in Table 1 is very significant. The large uncertainties make it meaningless to calculate the mineral composition of this material from the chemical composition. However, it is clear that the higher Fe content will result in a significantly higher density than that of terrestrial basalt. The measured density of eucrites at atmospheric pressure ranges from 3.00 to 3.30 (*7*). The density of a mixture consisting of pyroxene, plagioclase, and metallic iron in the proportions found in average eucrites is 3.25. The chemical result from Surveyor V thus suggests that the density of compacted surface material is rather similar to the mean density of the moon, 3.35. If the observed chemical composition is typical, the density contrast between the surface of the moon and interior of the moon may be relatively small.

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