We limited our discussion to sorption of neutral compounds from water (1). Based on the observed soil-water equilibrium data, we suggested that these compounds are taken up primarily by soil organic matter through partitioning. The soil inorganic fraction does not make a significant contribution in aqueous systems, presumably because of its strong dipole interaction with water, which precludes active association of these compounds with this portion of the soil. In nonaqueous systems, the contribution of soil minerals can be important even for neutral (especially polar) compounds.

Our discussion of the heat effect in soil-water systems was based on the temperature dependence of the equilibrium constants (that is, the slopes of the isotherms). Calculations of the enthalpy change $\Delta \bar{H}$ from a Clapeyron-type equation involve no restrictions on the number of components in the systems. The $\Delta \bar{H}$ for a partition process must, in principle, be equal to the difference in heats of solution in the two equilibrating phases. For adsorption, $\Delta \bar{H}$ is always more exothermic than the heat of condensation in water.

Our hypothesis does not rule out the possibility of adsorption from an organic solvent or from the gas phase on dry and partially hydrated soils (2). A dehydrated soil might show significant uptake of a neutral solute from some nonpolar solvents by adsorption through dipole interactions or London forces on high-surface-area inorganic minerals (3), although partitioning of the solute to the organic matter may be weak because of its high solubility in the solvents (4). Thus, while uptake by the soil mineral fraction is unimportant in comparison with that by soil organic matter in aqueous solutions, the reverse may be true in nonpolar organic solvents such as hexane.

For parathion in dry soil–hexane systems, for example, we would expect that adsorption on the soil inorganic fraction would be largely responsible for the soil uptake and that such adsorption would be suppressed by the soil water (3), which can compete more effectively than less polar parathion for polar inorganic minerals. This analysis leads to the expectation that sorption of a neutral solute, such as parathion, on soil from polar organic solvents (for example, methanol, acetone, and dioxane) will be insignificant (3), because these solvents would wet the inorganic minerals effectively and their high solvating capability would reduce solute partitioning to the organic matter. The adsorption model suggested

by Kyle cannot explain the results in aqueous and nonaqueous systems.

Our reasoning, moreover, accounts for the anomalous temperature effect for the uptake of parathion in moist soil-hexane systems (3). The enhanced sorption at higher temperatures is apparently caused by the gradual weakening of dipole interactions between water and soil minerals, assisting parathion in competing for this portion of the soil. This analysis also explains to a large extent the finding of Spencer and Cliath (5) that the vapor density of lindane applied to a hydrated soil has a smaller temperature coefficient than that of pure lindane. The ability of the soil mineral fraction to adsorb lindane would be lost due to the presence of water, restricting lindane to partition to the soil organic phase. Thus, the vapor density would be much higher in the hydrated soil than in the dehydrated soil. Hance's observations (6) of the sorption of a pesticide (diuron) from aqueous and petroleum solutions are also consistent with this analysis.

Kyle's view of the Polanyi theory appears to be incomplete. First, the isotherm assumed by his Eq. 1 is nonlinear, since solute condensation is implied (7). Second, the scaled adsorption potential curves (ϕ versus ϵ/V) are the same only for chemically similar compounds that have nearly identical polarizability per unit (molar) volume, or refractivity per unit volume (8). The difference in the values of ϵ/V for different compounds at fixed loadings may be related to their refractivities per unit volume or refractive indices (9). We were unable to apply the Polanyi model because it could not be reconciled with the high degree of linearity of the soil-water isotherms.

Nonlinearity is normal in Polanyi isotherms, whereas linearity is limited to very low relative concentrations (C_e/C_s). Similarly, a Langmuir isotherm is indistinguishable from a linear partition isotherm only in the limit of low relative concentrations. Our high-concentration data and observed heat effects cannot be reconciled with a Langmuir equation.

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2. More data have been obtained in our laboratory to address this problem. The results are now in preparation for publication.
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An Upper Bound to the Lightning Flash Rate in Jupiter's Atmosphere

Lewis (1) discussed Voyager optical measurements and low-frequency radio-wave observations related to lightning discharges in the atmosphere of Jupiter. He used a specific set of assumptions together with whistler measurements from the plasma-wave system to arrive at estimates of the average planetary lightning stroke rate r ranging between 10^{-4} and 4×10^{-2} flashes per square kilometer per year. Here we show that when the same Voyager whistler data are combined with different physical assumptions about the source area, the whistler paths, and the whistler amplitude distributions over the paths, a planetary light-

ning rate as high as several tens of flashes per square kilometer per year cannot be ruled out.

The Voyager 1 wave instrument detected lightning whistlers only when the spacecraft was at a Jovicentric distance of about 5.5 to 6.0 Jupiter radii (R_J) near the equatorial plane. The Voyager event rate was about 0.12 whistlers per second (2), and the ray-tracing analysis by Menietti and Gurnett (3) confirmed that these whistlers originate at high latitudes ($\approx 66°$) near the feet of the field lines passing through the Io torus. The geometric situation is indicated in the upper part of Fig. 1, which shows Jupiter, some

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Soil-Water Equilibria for Nonionic Organic Compounds

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