

This unexpected result seems to indicate that the retarding effect of the heavy water on the alcoholic fermentation might be due to a decreased activity of the zymase complex occasioned by an irreversible, partially destructive action of the heavy water on the enzymes. Further experiments with the object of studying the effect of D₂O on extracellular enzymatic reactions are in progress in this Laboratory.

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SOME PHARMACOLOGICAL EXPERIMENTS WITH DEUTERIUM

Sir:

In consideration of the brief reports concerning physiological effects of deuterium, published by Lewis [THIS JOURNAL, 55, 3502(1933)], who found it affected the germination of tobacco seeds, and Barnes [*ibid.*, 55, 4332 (1933)], who noted an inhibitory effect of heavy water on spirogyra, we deemed it desirable to perform a series of pharmacological experiments with heavy water. Agreeing with Barnes that the most valuable practical information would be gleaned from experiments with weak solutions of deuterium, we employed a heavy water containing one part of deuterium to two thousand parts of protium, purchased from the Ohio Chemical and Manufacturing Company, which was of practically the same specific gravity (1.000060).

I. Germination of *Lupinus* seeds, soaked in this solution overnight, was studied by phytopharmacological methods described elsewhere [*Science*, 71, 302 (1930); *J. Gen. Physiol.*, 4, 573 (1922)]. It was found that the germination of seedlings in 1:2000 deuterium solution was slightly inhibited as compared with their growth in ordinary, glass-distilled water.

II. Growth of *Lupinus* seedlings in Shive's physiological saline [*Physiological Researches*, 1, 327 (1915)], prepared with and without deuterium solution, respectively, revealed that the latter solution produced slight inhibition. Comparison of seedlings grown in deuterium saline with the controls showed that this difference, 5 to 10%, easily explainable by variations in the hydrogen concentration, was insignificant.

III. Fermentation experiments with bakers' yeast and 4% cane sugar dissolved in ordinary

and deuterium water, showed no difference in their activity.

IV. Mice injected with physiological and sodium chloride solutions, prepared with and without deuterium, respectively, exhibited no toxic action.

V. Goldfish, *Carassius Auratus*, behaved exactly alike when placed in ordinary and deuterium water, respectively.

VI. Surviving pieces of cats' intestines, suspended in oxygenated Locke's solution prepared with ordinary, distilled water and in deuterium water, showed no difference in normal rhythmic contractions of smooth muscle or response to pilocarpine and mono-brom saligenin [*Proc. Soc. Exptl. Biol. Med.*, 30, 378 (1932)].

VII. Similar experiments with vasa deferentia of white rats showed no difference in contractions of such organs to epinephrine and corpus luteum.

VIII. Similar experiments with surviving segments of guinea pig uteri revealed no difference in the action of normal and deuterium Locke's solution.

IX. Intravenous injection into cats under ether of physiological saline itself, prepared with and without deuterium, revealed no difference in effect on blood pressure and respiration.

X. Identical results were obtained by assay of digitalis tincture on cats with ordinary and deuterium saline, respectively.

Our experiments indicate that when deuterium water is employed in concentrations of 1:2000, or less, no striking physiological or pharmacological effects are noted, except possibly a slight inhibitory influence on germination of some seeds. This does not preclude the possibility of more profound biological changes being produced by pure or very concentrated heavy water. Furthermore, since the plant-physiological preparations employed by us were not the same as those described by Lewis and Barnes, no factual contradiction between our experiments and theirs need be inferred. However, if a speculative *a priori* conjecture may be permitted, we doubt that weak concentrations of deuterium would produce remarkable biological effects, for we are probably all dealing with isotopes of many elements in our physiological, pharmacological and biochemical work.

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