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THE BEGINNINGS OF SOCIAL BEHAVIOR IN UNICELLULAR ORGANISMS[1]

By Professor H. S. JENNINGS

THE UNIVERSITY OF CALIFORNIA AT LOS ANGELES

BY social behavior we mean the behavior and reactions of individuals with relation to other individuals as such; reactions to individuals as individuals, either singly or in combination, not merely reactions to physical forces or to masses present in the environment.

How far down in the biological scale does such social behavior extend? Are social urges and instincts and reactions part of the life of the very cells of which organisms are made? Or are they manifestations only of relations that have first come into existence in the great complexes of cells that constitute higher organisms?

I have of late been forced in the course of investigations to become intimately familiar with the daily and most private life of certain organisms, each of which is a single microscopic cell. The phenomena that thus come under observation throw light on the most primitive manifestations of social behavior. I shall try to present the main features of these phenomena, with certain of the reflections and conclusions to which they give rise. They raise the question: What is the nature of the earliest manifestations of social behavior; and perhaps they help us to answer it. They bear also upon the problem of the unity of the manifestations of life in higher and lower organisms. And they lead to a reconsideration of certain other questions that are related to the problems of social behavior: particularly to a question that has been discussed as the problem of self-consciousness in animals.

[1] Leidy Lecture, delivered before the section on Natural Sciences of the University of Pennsylvania Bicentennial Conference, Philadelphia, September 18, 1940.

of rats maintained on a diet devoid of pantothenic acid. These results are in apparent conflict with observations made in the writer's laboratory. In our experiments, neither pantothenic acid concentrates nor pure pantothenic acid exhibited a preventive or curative effect on the gray hair of rats, although the rate of growth and the length of life were greatly enhanced. Evidently, some other circumstances which we can not as yet define influence the occurrence of achromotrichia. We note that our diet differs from that of György and Poling most conspicuously in the substitution of 8 per cent. butter for 2 per cent. corn oil. Such a difference might result in significantly differing amounts of the factor described by Nielsen, Oleson and Elvehjem.[2]

Our rats in which graying of hair occurred were maintained on the following basal diet: sucrose (or starch) 76 per cent., purified casein 18 per cent., salts 4 per cent., and corn oil 2 per cent., supplemented with 24 micrograms B_1, 40 micrograms B_2, 50 micrograms B_6, 6 mgs nicotinic acid and 6 mgs choline every other day and two drops of halibut liver oil weekly.

Group 1. Five litter mates, 2 black, 1 piebald, 1 tan and 1 white, received the basal sucrose diet. The two black rats as well as the tan one received, in addition to the above vitamins, every other day, 0.571 mg of Ba pantothenate of 40 per cent. purity derived from natural sources. Gray hair was observed in both black rats on the 16th day after the Ba pantothenate was first instituted and persisted until the experiment terminated four and one half months later. The tan rat on Ba pantothenate showed no changes in the fur. The white and piebald rats which received no Ba pantothenate developed a "rustiness" of the fur around the head on the 20th and 27th day, respectively.

Group 2. This group was composed of seven black littermates. Five of them were maintained on the above basal sucrose diet, while the remaining two received a basal diet in which methanol extracted starch was substituted for the sucrose. Three of the five rats on the sucrose diet received, in addition to the above vitamins, 4 mgs of methanol starch extract every other day. All five rats on the sucrose diet developed gray hair by the 28th day of the experiment. Two days later the starch extract was discontinued in the three rats receiving this supplement and two days later all seven rats were thereafter given 500 micrograms Ba pantothenate of 40 per cent. purity every other day. On the fifth day after the institution of Ba pantothenate, graying of the fur was observed in the two rats on the extracted starch diet. Two of the sucrose rats also showed "rustiness" of the fur about the head while on the Ba pantothenate. Twenty-five days after the institution of Ba pantothenate, 4 gms of wheat bran extract were given every other day to the three rats which had originally received the starch extract and to one of the rats on the extracted starch diet. The graying persisted in all rats during the subsequent six weeks. At this time pure Ca pantothenate became available and was substituted for impure Ba pantothenate in the amount of 200 micrograms Ca pantothenate every other day. Four of the rats on the sucrose diet and one on the extracted starch diet showed no improvement in gray hair during the subsequent two weeks, while the remaining two rats, one on sucrose and wheat bran extract and one on the extracted starch diet and wheat bran extract, showed a general decrease in graying.

Group 3. Thirteen black rats were maintained on the above sucrose diet supplemented with 6 mgs vitamin C, 200 micrograms vitamin K and 500 micrograms Ba pantothenate of 40 per cent. purity in addition to the previously mentioned vitamins every other day, and 21 mgs alpha tocopherol and 350 mgs linseed oil weekly. In addition, four of the rats received 2 gms waste cane molasses, three received 4 cc steep water, a by-product of starch manufacture, and three were given 400 mgs wheat germ every other day. Five weeks later, pure Ca pantothenate became available and was substituted for 40 per cent. pure Ba pantothenate in the amount of 200 micrograms every other day. By the 11th day after Ca pantothenate was first instituted, all the rats receiving wheat germ and steep water, one of the four receiving molasses and one of the three receiving none of these special supplements developed gray hair. On the 25th day, graying was observed in the remaining three rats on molasses and in one of the two remaining rats receiving none of the special supplements. The other rat of this latter group never developed gray hair.

The pantothenic acid salts used were kindly supplied in part by Merck and Company, Inc., Rahway, N. J. and in part by Professor R. J. Williams, of the University of Texas.

R. R. WILLIAMS

SUMMIT, N. J.

[2] E. Nielson, J. J. Oleson and C. A. Elvehjem, *Jour. Biol. Chem.*, 133: 637, 1940.

BOOKS RECEIVED

ALEXANDER, EDWIN P. *Model Railroads.* Pp. 283. 206 figures. Norton. $4.00.

CLAUSEN, CURTIS P. *Entomophagous Insects.* Pp. xv + 688. 257 figures. McGraw-Hill. $7.00.

FISHER, CLYDE and MARIAN LOCKWOOD. *Astronomy.* Pp. ix + 205. 66 figures. Wiley. $2.25.

GUGGENHEIM, M. *Die biogenen Amine.* Pp. xvi + 564. Nordeman, New York.

PARSHLEY, HOWARD M. *Biology.* Pp. ix + 232. 80 figures. Wiley. $2.25.

PEATTIE, RODERICK. *Geography in Human Destiny.* Pp. 323. 26 figures. Stewart, New York. $3.00.

ULICH, HERMANN and HABIL K. CRUSE. *Kurzes Lehrbuch der Physikalischen Chemie.* Pp. xvi + 324. Illustrated. Steinkopff, Dresden.