were one hundred and ten tubes of controls and thirty-one tubes of the treated. No mutations occurred in the controls, while four out of the thirty-one treated tubes showed lethal mutations. This is a mutation rate of 12.9 per cent. While numbers so small as these may have little value in themselves they pointed the direction for further work.

Experiment II. This experiment was an exact repetition of the first one, with the addition of a group in which gamma rays only were permitted to reach the flies during treatment. This was accomplished by enclosing the glass vial containing the flies in a cylinder of soft lead. The lead in this cylinder was two millimeters thick and effectively stopped both the alpha and beta rays. Since it also reduced the amount of gamma rays the time of treatment was extended from six to thirteen hours.

The following table gives the results of the second experiment. In the column marked "dosage" it will be noted that 140 milligrams of radium were used instead of the usual 150 milligrams, one ten mg. needle not being available at that particular time.

	Dosage	Number F_2 tubes	Number lethal mutations	Percentage of mutation
Control	———	423	0	0
Radium	140 mg. radium 6 hours	426	35	8.2
Gamma rays only	150 mg. radium 13 hours	426	12	2.8

Five hundred tubes each of controls, "all radium" and "gamma only," were made up. All sterile tubes were eliminated from the experiment, so the numbers in column 3 of the table represent fertile pairs.

In the "all radium" group the mutation rate is 8.2 per cent., while in the first experiment it was 12.9 per cent. The reasons for this difference are at least two: first, there were ten milligrams less of radium and, second, the difference in size between the two samples, thirty-one tubes in the first experiment and 426 in the second, might well give a difference as great as this. There is a striking difference between the rate of mutation in the "all radium" group (8.2) and the "gamma only" group (2.8). This may be due to the fact that the beta rays are also effective in causing mutations, or, as we have learned since, the time was not sufficiently extended to give the same amount of gamma radiation as in the "all radium" group. More probably both factors were responsible for the difference.

As the results stand now the two experiments show that radium emanations produce lethal mutations in Drosophila and that gamma rays alone will also do the same thing. This is the first step in the analysis of just what elements in radium and X-rays are responsible for the results obtained. Further work on the analysis of the three rays of radium is now under way.

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THE NATURE OF THE ACIDIC SUBSTANCE FORMED ON THE HYDROLYSIS OF ACACIA

DURING the course of a study of the acid polysaccharides occurring in plants, we have had occasion to devote considerable time to the chemistry of acacia or gum arabic.

The plant gums, as is well known, are salts of very complex organic acids, usually with calcium, magnesium and potassium. These complex acids are built up of hexose, pentose and methyl pentose units in combination with the acidic part of the molecule. Many gums liberate carbon dioxide on heating with 12 per cent. hydrochloric acid,[1] and they give the naphtho-resorcin test.[2] It is therefore believed that they contain *uronic* acid units.[3]

But little work has been done on the acidic nucleus of gums since the researches of O'Sullivan.[4] This author found that arabic acid—from gum arabic—on heating with dilute sulphuric acid yielded an acid of lower molecular weight which he called λ-arabinosic acid and which was stable enough to resist the action of 3 to 4 per cent. sulphuric acid—at 100°—for several hours. He assigned to the substance the formula $C_{23}H_{38}O_{22}$ from the results of the analysis of its barium salt.

We have planned to make an extensive study of gum arabic in this laboratory, and as a part of our program have submitted a botanically authentic sample of the gum to hydrolysis with dilute sulphuric acid under much the same conditions as those employed by O'Sullivan.

The acidic product of the hydrolysis appears to be identical with the λ-arabinosic acid of the earlier investigator. The substance has been isolated and analyzed in the form of its calcium salt. The analytical

[1] Nanji, Patton, Ling, *J. Soc. Chem. Ind.*, 44, 253T (1925); Anderson and Sands, *J. Am. Chem. Soc.*, 48, 3172 (1926).

[2] Tollens, Ber. 41, 1788 (1908).

[3] Widsoe and Tollens, Ber. 33, 132 (1900); see also ref. (1).

[4] *J. Chem. Soc.*, 45, 41 (1884); *ibid.*, 59, 1029 (1891); *ibid.*, 79, 1164 (1901).

figures indicate an aldobionic acid of formula $C_{12}H_{20}O_{12}$. In fact O'Sullivan's analytical data agree better with the requirements of the barium salt of an aldobionic acid than with the barium salt of a dibasic acid of formula $C_{23}H_{38}O_{22}$. It gives a strong naphtho-resorcin test and reduces Fehling's solution vigorously. On boiling with 12 per cent. hydrochloric acid, the correct amount of carbon dioxide is liberated and the glucose value, calculated from the amount of iodine consumed in oxidation, as well as the percentage of calcium found, corresponds to the requirements of a compound of formula $C_{12}H_{20}O_{12}$ containing one aldehyde and one carboxyl group.

Aldobionic acids are substances new to chemistry, and to date have been found only in the soluble immune substances produced by bacteria, *e.g.*, pneumococcus Types II and III, and by Friedlander's bacillus,[5] Types A, B and C.

It has been said that true gums are never formed except by the decomposition of vegetable tissue due to a diseased condition of the plant. Some authorities have claimed that this morbid process is the result of bacterial action,[6] and, if this is true, it is not surprising that an aldobionic acid would be found.

We have not as yet identified either the uronic acid or the sugar component of this aldobionic acid, but are at present engaged in the solution of the problem.

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VARIETY OF BEHAVIOR OF LARVAL TREMATODES

The life cycle of most trematode parasites includes two free-swimming stages: the miracidium and the cercaria. The mature worm, parasitic with few exceptions in a vertebrate, produces eggs which develop into miracidia; these hatch out in water and then penetrate an invertebrate intermediate host, which is almost always a gastropod mollusk. From the point of entry the miracidium usually makes its way to, and lodges in, the hepato-pancreas or the gonad; here it metamorphoses into a sporocyst, the first of a series of parthenogenetic reproductive stages (daughter sporocysts or rediae or both) the last of which finally produces in large numbers a larva known as a *cercaria.* The cercaria of most species deserts the mollusk host and has a period of free-swimming existence which lasts at most several days. The tail of the cercaria, in many cases a highly modified larval swimming organ, is cast off at the beginning of post-larval development, when the cercaria penetrates the body of an intermediate invertebrate host, or, in a few species, the definitive vertebrate host.

The morphology of a great many cercariae has been more or less completely described, but no detailed studies have been made of their behavior, which is varied and is of interest from a number of standpoints. Observations and preliminary experiments made by the author on representatives of various groups of cercariae, chiefly fresh-water ones, from Illinois, Michigan, Missouri, Washington, and from Woods Hole and the Dry Tortugas justify the expectation that larval trematodes are an important source of experimental material, especially for a study of the responses of animals to changes of light intensity.

In so far as these larvae have been studied it has been found that the swimming behavior of each species is distinctive; the only time that preliminary observations failed to show differences between species was in the case of two which have only slight morphological differences. In most cases examination of living cercariae with the unaided eye, or with a hand lens, is sufficient to distinguish among the species found in a locality; but it is not true that species of furcocercous cercariae with long furcae may be thus differentiated, except by closer examination. From the standpoint of the parasitologist it will be interesting to determine in what ways the swimming behavior and the responses to stimuli normally encountered in nature play a rôle in the life history of the species.

Unstimulated swimming behavior. Locomotion is effected principally by vigorous movements of the extensile and usually very muscular tail. Some species swim almost, if not quite, incessantly from the moment of liberation from the host; but the greater number are intermittent swimmers. Among the species in either group considerable variations occur in swimming behavior. Some of these are described in this paper.

Among the *incessant* swimmers the individuals of one species swim close to the surface of the water with rapid and sudden changes of direction, while those of another species swim erratically throughout the container; in some species locomotion is very slow. The individuals of a few species aggregate in the most illuminated part of the container. In the *intermittent* swimmers a period of passive sinking alternates with a period of locomotion upward, usually in a more or less vertical path. During the period of passive sinking the individuals of most species are motionless, or almost entirely so; the length of this period gradually increases until finally the cercariae come to rest on the bottom. From this position, or during the period of sinking, they may suddenly swim

[5] Heidelberger and Goebel, *J. Biol. Chem.*, 74, 613 (1927); *ibid.*, 74, 619.

[6] G. Smith, *J. Soc. Chem. Ind.*, 23, 972 (1904).