treated in great detail, the present section merely states the main experimental facts and brings the material up to date. The chapter on the emission of positive and negative electrons completes the usual discussion of beta-ray spectra by the inclusion of data on the emission of positrons and electrons from light elements made radioactive by bombardment. The foundations and results of Fermi's theory of beta particle disintegration are clearly discussed and the connection between this theory and Sargent's curves is pointed out. The recent experiments concerning the existence (or perhaps non-existence) of the neutrino are described.

The final section of the book—Part IV—deals with transformations produced by high energy particles and light quanta. The effects produced by alpha-particles, neutrons, accelerated particles and quanta are described in turn. The discussion is well ordered and entirely free from the confusion with which one is confronted if one has to go to the original sources for information. The usefulness of these sections is enhanced considerably by the inclusion of a section entitled "collected results" at the end of each chapter. These sections contain in tabular form all the useful information which has been accumulated to date on induced disintegration.

The book contains an unusually complete list of references. In fact, references to papers published in this country as late as July, 1936, and to English papers published after the book was printed are to be found. The theoretical discussions are treated mostly from the physical standpoint without the use of mathematics. The book should be of great interest both to the specialist in nuclear physics and to one who merely wishes to find out what the nuclear physicist is doing.

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# SPECIAL ARTICLES

## VITAMIN $B_1$ AND THE GROWTH OF EXCISED TOMATO ROOTS

IN 1922 one of the authors[1] reported a method of cultivating excised root tips under sterile conditions, and found the growth of excised roots of corn (*Zea mays* L.) to be limited in extent in a modified Pfeffer's solution containing dextrose. As a working hypothesis it was assumed that oxygen, the mineral salts of Pfeffer's solution, glucose and water were insufficient for the continued growth of excised corn roots. In the same year Robbins[2] reported the beneficial effects of autolyzed yeast on the growth under sterile conditions of the excised root tips of corn. Various evidences were presented and discussed, indicating that the yeast was effective by furnishing some accessory growth factor or factors originally supplied to the root tip from the grain but fractionated in subculturing the root tips. The same hypothesis was considered in later papers. However, it was not possible at that time definitely to determine in what the effectiveness of the yeast consisted.

White[3] demonstrated potentially unlimited growth for excised root tips of tomato (*Lycopersicon esculentum* L.) in a solution containing mineral salts, cane sugar and yeast.

Since September, 1935, we have cultivated excised tomato root tips in White's solution, thus confirming his original report of the possibility of unlimited growth of the root tips of this plant. We have found that excised tomato root tips which have been subcultured for some time will not grow in White's solution if the mineral salts are omitted, leaving the cane sugar and yeast only. They will not grow if the cane sugar is omitted; nor will they grow if the yeast is omitted and only cane sugar and mineral salts are present.

The effective materials in the dried yeast are not soluble in absolute ethyl alcohol but are soluble in 80 per cent. alcohol. The residue left after extraction with absolute and 80 per cent. ethyl alcohol is ineffective. The beneficial action of the yeast is not eliminated by autoclaving for 12 hours at 120° C. at pH 9.0. Yeast ash prepared by ashing at low red heat in a muffle furnace will not replace the yeast.[4] However, we have found excised tomato roots to grow in White's solution in which the yeast is replaced by natural crystalline vitamin $B_1$ Merck or by synthetic vitamin $B_1$ Merck.[5] The vitamin is effective at great dilution. Growth of root fragments has been secured in 50 cc of White's solution without yeast to which $1 \times 10^{-4}\gamma$ of natural crystalline vitamin $B_1$ Merck was added. No growth was secured in the same solution lacking both yeast and the vitamin. The vitamin in this solution was present at a concentration of 1 part in $5 \times 10^{11}$ parts of liquid or $2 \times 10^{-6}\gamma$ per cc, a dilution of the same order as that found by Kögl[6] to be effective for

1 William J. Robbins, *Bot. Gaz.*, 73: 367–390, 1922.
2 *Idem.*, *Bot. Gaz.*, 74: 59–79, 1922.
3 P. R. White, *Plant Physiol.*, 9: 585–599, 1934.

4 The authors are indebted to F. Kavanaugh for the preparation of the yeast fractions and for other assistance.
5 The authors express their appreciation of the assistance of R. R. Williams in securing this material and to Merck and Company for the gift of the synthetic vitamin $B_1$.
6 Fritz Kögl, and Benno Tönnis, Hoppe-Seyler's *Ztschr. f. physiolog. Chem.*, 242: 43–73, 1936.

crystalline biotin on yeast. We have not yet determined the lower limit of effectiveness, though we have found concentrations up to 1γ per cc to be harmless and little better than the more dilute solutions. The extreme dilution at which the vitamin is effective accounts for our failure to inactivate yeast by long heating under pressure at an alkaline reaction; the vitamin is not completely destroyed under such conditions and sufficient remains to be effective. The insolubility in absolute alcohol of the effective factors in the dried yeast is probably apparent only. That the vitamin and not some contaminant is the effective agent would seem to follow from the dilutions at which the vitamin is used and because the contaminants are probably not the same in the synthetic and natural products, both of which are effective.

The beneficial effects of yeast on the growth of the root tips is not completely accounted for by the vitamin $B_1$ content of the yeast, since the growth in White's solution containing yeast is better than in the same solution in which the yeast is replaced by vitamin $B_1$. Part of the beneficial effect of the yeast is due to the ash elements in it, since growth is improved by the addition of yeast ash to White's solution in which the yeast is replaced by vitamin $B_1$ and the growth in the latter solution is improved also by the addition of supplementary mineral elements. We have not yet determined whether amino acids, hormones or vitamins other than $B_1$ present in yeast play a significant rôle in the cultivation of excised tomato root tips.

Our results show that excised tomato roots grow if supplied with water, oxygen, mineral salts, carbohydrate and vitamin $B_1$. These results are similar to those of Schopfer[7] for *Phycomyces Blakesleeanus* which he has found requires vitamin $B_1$, though this organism apparently requires asparagine also in addition to mineral salts, carbohydrate and the vitamin. It appears that a medium containing mineral salts, carbohydrate and vitamin $B_1$ is adequate for the unlimited growth of tomato roots. We have grown excised tomato roots successfully for five months in such a medium through four subcultures without evident diminution in growth rate. Such a medium is composed of known constituents and may be regarded as a synthetic medium adequate for the growth of tomato roots.

Whether any substitute for vitamin $B_1$ can be found remains to be determined. Present evidence indicates that pantothenic acid (a highly purified sample furnished the writers by R. J. Williams) can not be substituted for vitamin $B_1$. Another aspect of the problem of general interest and significance is the possible occurrence of vitamin $B_1$ in highly purified sugars. Judging from the response of excised tomato roots, growth factors (probably vitamin $B_1$) are present in samples of purified maltose and dextrose secured from various companies. Hall, James and Stuart[8] have reported the occurrence of growth stimulants for yeast in white sugar, and Schopfer[7] found a growth factor for *Phycomyces* in maltose.

Our results confirm the working hypotheses originally formulated to explain the beneficial action of yeast on the growth of excised roots in a mineral solution containing sugar and demonstrate that the parasitic relationship of the tomato root to the top involves both carbohydrate and vitamin $B_1$.

Whether the medium the writers have used is adequate for all types of plant tissue remains to be seen; the results, however, are significant in presenting a synthetic solution apparently adequate for the growth of one type of plant tissue and should be of interest to those engaged in the cultivation of isolated plant embryos and other portions of higher plant tissues.

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## THE SIGNIFICANCE OF THE ADRENALS FOR ADAPTATION[1]

IN the course of our studies on the alarm reaction[2,3] we found that the symptoms of adrenal deficiency are almost identical with those observed in non-adrenalectomized animals after exposure to serious damage. Decreased blood pressure; accumulation of water in tissues, with a simultaneous loss of water from the blood; decreased blood sugar; decreased body temperature; muscular weakness; formation of gastric and intestinal ulcers; are the most characteristic features both of adrenalectomy and of the alarm reaction. We have to conclude, therefore, that there is no specific change characteristic of adrenal deficiency, and that the changes observed after the removal of the adrenals are simply due to the response of the organism to general damage—that is to say, they are changes caused by the alarm reaction. We found, furthermore, that alarming stimuli (*i.e.*, stimuli which would elicit an alarm reaction) will cause much more pronounced changes in adrenalectomized animals than these same stimuli would be able to produce in the normal. This

[7] W. H. Schopfer, *Ber. deut. bot. Ges.*, 52: 308–313, 1934.

[8] H. H. Hall, L. H. James and L. S. Stuart, *Jour. Ind. and Eng. Chem.*, 25: 1052–1054, 1933.

[1] A detailed publication of the experimental data mentioned in this letter will shortly appear in the "Archives Internationales de Pharmacodynamie et de Thérapie."

[2] H. Selye, *Can. Med. Assoc., Jour.*, 34: 706, 1936; *Nature*, 138: 32, 1936; *Brit. Jour. Exper. Pathol.*, 17: 234, 1936; *Endocrinol.*, in press.

[3] H. Selye, C. Harlow and J. B. Collip, *Endokrinol.*, 1936.