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TRANSMUTATIONS OF ATOMIC NUCLEI¹

By Professor NIELS BOHR

INSTITUTE OF THEORETICAL PHYSICS, UNIVERSITY OF COPENHAGEN

It has been pointed out on an earlier occasion² that in order to understand the typical features of nuclear transmutations initiated by impacts of material particles it is necessary to assume that the first stage of any such collision process consists in the formation of an intermediate semi-stable system composed of the original nucleus and the incident particle. The excess energy must in this state be assumed to be temporarily stored in some complicated motions of all the particles in the compound system, and its possible subsequent breaking up with the release of some elementary or complex nuclear particle may from this point of view be regarded as a separate event not directly connected with the first stage of the collision

¹ Abstract of lectures given in the spring of 1937 at various universities in the United States. The illustrations are reproductions of three slides shown in these lectures.

² N. Bohr, *Nature*, 137: 344, 1936.

process. The final result of the collision may therefore be said to depend on a competition between all the various disintegration and radiation processes from the compound system consistent with the conservation laws.

A simple mechanical model which illustrates these features of nuclear collisions is reproduced in Fig. 1, which shows a shallow basin with a number of billiard balls in it. If the bowl were empty, then a ball which was sent in would go down one slope and pass out on the opposite side with its original energy. When, however, there are other balls in the bowl, then the incident one will not be able to pass through freely but will divide its energy first with one of the balls, these two will share their energy with others, and so on until the original kinetic energy is divided among all the balls. If the bowl and the balls could be regarded as perfectly

symptoms which have been considered characteristic of a deficiency of manganese.

Recently a problem involving the production of alfalfa has become acute in North Carolina. The terminal leaves become yellow without distortion, apical buds do not develop normally, plants wilt badly in dry weather and severe infestation with aphids and leaf-hoppers has been noted. Very heavy applications of lime have been made to the soil on which these characteristics were first noted.

Borax, applied at a rate of five pounds to the acre in March, effectively corrected the abnormal conditions during the same year, but a similar treatment applied late in May did not produce any visible effect until the following year. Tentatively, it is suggested that there is a photoperiodic factor involved.

Manganese appears to supplement the effect of borax, while zinc is antagonistic. The influence of copper is negligible.

A casual survey of alfalfa fields throughout the state has shown that this condition is general on all soils. It seems to have been aggravated by the liberal use of fertilizers high in calcium salts. It conforms in all respects to the description of "alfalfa yellows," which has been considered to be a transmissible disease.

Photographs illustrating this effect of borax were exhibited at the meeting of the American Society of Agronomy in Washington, from November 17 to 20, 1936.

L. G. WILLIS
J. R. PILAND

NORTH CAROLINA AGRICULTURAL
EXPERIMENT STATION

ENZYMIC SYNTHESIS OF CO-CARBOXYLASE

CO-CARBOXYLASE has been obtained synthetically from vitamin B₁ and orthophosphate (a) by an enzymic system of dried yeast from which the natural co-carboxylase had been removed by extensive washing, and (b) by an enzyme of the duodenal mucosa of the pig.

(a) *Synthesis by Washed Yeast*: To one mg synthetic vitamin B₁¹ 2 cc of Sørensen's phosphate of pH 6.7 was added. The solution was adjusted to pH 6.7 and diluted to 3 cc with distilled water. Five cc of washed dry yeast² in 6.7 phosphate was added. The mixture was kept at 30° for 24 hours. Then it was boiled for 4 minutes and centrifuged. The supernatant fluid contained the synthetic co-carboxylase.

(b) *Synthesis by Duodenal Mucosa*: Mucosa of pig's duodenum was washed with water, dried in a

¹ I am indebted to Merck and Company, through the kindness of Dr. R. T. Major, for furnishing a sample of their synthetic vitamin B₁.

² The dry yeast was prepared by keeping Fleischmann's yeast in an air current at 38° for about three hours. It was washed according to Lohmann and Schuster.³

current of air at 38°, extracted once with ether and four times with acetone. Each extraction was applied for 10 minutes, using the same weight of solvent as the original weight of mucosa. The defatted mucosa was dried at room temperature and powdered. To 500 mg dry powder, 7 cc phosphate of pH 6.8 and one mg of vitamin B₁ were added, and adjusted to pH 6.8. A control was prepared in a similar manner, the vitamin being added just before testing. Both samples were kept for 24 hours at 30°. Then they were boiled for four minutes and centrifuged. The supernatant fluid of the first sample contained the co-carboxylase.

Natural co-carboxylase had been recently isolated in crystalline form from bottom yeast by Lohmann and Schuster.³ They found that the co-carboxylase is pyrophosphoric ester of vitamin B₁. More recently Stern and Hofer⁴ reported the synthesis of co-carboxylase from vitamin B₁ and POCl₃. These investigators, however, were unable to obtain co-carboxylase by an enzymic reaction.

The yield of co-carboxylase prepared by enzymic synthesis is nearly 100 per cent., while by POCl₃ synthesis it is about 2 per cent.

HENRY TAUBER

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³ K. Lohmann and Ph. Schuster, *Naturwiss.*, 25: 26, 1937; *Angew. Chem.*, 50: 221, 1937.

⁴ K. G. Stern and J. W. Hofer, *SCIENCE*, 85: 483, 1937.

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- Annales de la Universidad Central. Tomo LVIII, Num. 300. Abril-Junio de 1937.* Pp. 625. Illustrated. Universidad Central del Ecuador, Quito. Numero Suelto, \$2.00.
- DODGE, RICHARD E. and STANLEY D. DODGE. *Foundations of Geography.* Pp. xi + 490. 264 figures. Doubleday, Doran. \$3.75.
- HAWLEY, RALPH C. *The Practice of Silviculture with Particular Reference to Its Application in the United States of America.* Fourth Edition. Pp. xiv + 252. 68 figures. Wiley. \$3.00.
- Indian Science Abstracts. (Being an Annotated Bibliography of Science in India.)* 1935, Part II. Pp. 224. National Institute of Sciences of India, Calcutta. 12 Rupees.
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- MATHEWS, F. SCHUYLER. *Familiar Flowers of Field and Garden.* Revised Edition. Pp. xv + 310. D. Appleton-Century. \$2.50.
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- SAUVEUR, ALBERT. *Metallurgical Dialogue.* Pp. iii + 166. Illustrated. American Society for Metals, Cleveland.

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