OBITUARY NOTICE.

CHAIM WEIZMANN.

1874—1952.

On November 9th, 1952, Dr. Chaim Weizmann, distinguished chemist and first President of the State of Israel, died after a long illness at his home in Rehovoth.

Born on November 27th, 1874, in Motol in Czarist Russia, in the pale of Jewish settlement, Weizmann was a representative of that gifted type of Russian Jew who succeeded in the synthesis of the two antitheses, traditional Jewish culture and modern Western civilisation. Already in his youth, he joined the Zionist movement and rose quickly from the ranks to undisputed leadership. His thirst for knowledge, his interest in natural science which also had its roots in his school days, led Weizmann to the study of chemistry, and his achievements in this field were no mean ones. These two different directions of human endeavour, however, did not appear to be divergent in Weizmann's life; to him work in his profession was but one of the means of rebuilding of the Promised Land, and all his life he emphasised the role science would have to play in the State of Israel. Thus, he was the prime mover in the establishment of the Hebrew University, of the Hebrew Technical Institute of Haifa, and of the Daniel Sieff Research Institute, later enlarged into the Weizmann Institute of Science, at Rehovoth.

After having enjoyed the education traditional in Russian Jewry, Weizmann was sent in his 12th year to a Russian school (in Pinsk), at that time a somewhat unusual career for a Jewish youth. In his autobiography (" Trial and Error "), he describes the foundations his science teacher laid there for his later career. The *numerus clausus* at Russian Universities forced him, after having finished school, to turn westwards for further study. After a short sojourn at the University of Darmstadt, he enrolled in 1895 at the Technische Hochschule in Berlin-Charlottenburg, where at that time Liebermann was engaged with his pupils, notably Bistrzycki, in his classical studies in the polycyclic series. Weizmann followed Bistrzycki to Fribourg (Switzerland), where in 1900 he was awarded the degree of doctor *summa cum laude*. This rare distinction brought him an appointment as Privatdozent at the University of Geneva under Graebe who also recommended him to William Henry Perkin at Manchester University, when Weizmann, in 1904, decided to continue his work in England.

Weizmann's relation to England can only be described by the word " Wahlverwandtschaft," coined by Goethe. Undoubtedly, the period at Manchester was the happiest and scientifically the most creative in his life; it was there that he married Vera Chatzman, like him of Jewish–Russian origin. Of their two sons, one was killed on active service during the Second World War.

The faculty at Manchester was then adorned by some of the Immortals of British science; Weizmann was soon accepted into their community, and only the First World War severed this happy connection. It was one of the discoveries made at Manchester, that of a bacterium fermenting carbohydrates to yield acetone and butyl alcohol, which became of importance to the war effort and made it necessary for Weizmann—following an invitation by Lloyd George, then Head of the Ministry of Munitions, and Mr. Churchill, then First Lord of the Admiralty—to move to London. There, at the Lister Institute, and at the Admiralty Cordite Factory near Poole, the discovery was transformed into a technical process. It may be interesting to reflect that the " Weizmann fermentation " is but a further step on a road opened by another Manchester scholar, Arthur Harden, with his studies on the biochemistry of yeast fermentation.

The end of the war brought with it the Balfour Declaration and thus for Weizmann a measure of political responsibility which led to an interruption of his research until 1931, when his longing for scientific work became so overwhelming that he established a private laboratory at Featherstone Buildings, near High Holborn, in London. Here he took up some of his old subjects and initiated some new ones; at the same time, the Featherstone Laboratories became the planning centre for the Institute of Chemical Research which Weizmann established at Rehovoth and which bears the name of Daniel Sieff, son of one of Weizmann's closest friends and collaborators.

From April 4th, 1934, the day on which the new Institute was inaugurated, until the outbreak of the Second World War, Weizmann divided his time between the Institute in Palestine and the Featherstone Laboratories (which were destroyed by a German bomb early in the last war). In 1939, once more, Weizmann offered his services to the British Government and was appointed Scientific Advisor to the Ministry of Supply. A laboratory was put at his disposal at 25 Grosvenor Crescent Mews (London, S.W.1), and there soon began a number of investigations that appeared to be of importance to the war effort, amongst them the study of the formation of aromatic hydrocarbons by high-temperature cracking, the synthesis of isoprene from 3-methylbutyn-3-ol (the product of the condensation between acetone and acetylene), and various aspects of the acetone–butyl alcohol fermentation and of the utilisation of its products. The results of the work on aromatising cracking were verified in a pilot-plant erected by the Ministry of Supply and Messrs. Manchester Oil Refinery Ltd. at the plant of that firm in Trafford Park, Manchester, and were found to warrant the establishment of a large-scale factory, albeit after the end of the war. The results of Weizmann's other investigations became of considerable importance for the solution of the problem of synthetic rubber production, so that, in 1942, Weizmann was asked to visit America and to advise the Government of the United States on that problem. Mr. Henry Wallace, then Vice-President of the United States, later gave public acknowledgment to the services which Weizmann rendered the United States in the planning of the synthetic rubber programme.

Again, the end of the war with all its political implications brought Weizmann's scientific work to a standstill—this time for good. His health, particularly his eyesight, failed, and his work at the Sieff Institute was confined to advising and supervising the younger scientists who had gradually assembled there and later at the Weizmann Institute of Science. Every achievement of the Institute, however small, was for Weizmann a source of happiness and pride, and for some years the visit to the laboratory was part of his daily routine at Rehovoth, in spite of his political work and, later, his duties as President of the State. In 1951, his illness forced him to reduce his activities to a minimum, and gradually to give them up almost completely. He bore his illness with patience and the great dignity that was so characteristic of him.

Weizmann was a man of brilliantly clear mind and at the same time of deep, warmhearted gentleness, exacting towards his co-workers as towards himself, and at the same time generous, a son of the Jewish people and a citizen of the world, a statesman and a scientist. Nobody who knew him, nobody who met him, however, will ever have felt any duality in him—there was in him a oneness of character and purpose, a deep inner peace which made him the great man he was.

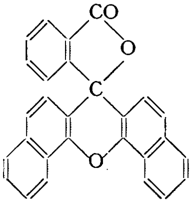
SCIENTIFIC WORK

Investigations in the Polycyclic Series and on Related Subjects.—The starting point of Weizmann's studies was the fact that, in contradistinction to aromatic hydrocarbons or aryl ethers, phenols give with phthalic anhydride under the influence of catalysts, such as zinc chloride, fluoran derivatives, *e.g.*, (I) with α-naphthol. He observed that boric acid yielded the normal keto-acid, 2-*o*-carboxybenzoyl-1-naphthol (II), which could be cyclised to 11-hydroxynaphthacene-5 : 12-quinone (III). This new route to the naphthacene series was systematically explored by Weizmann and his collaborators, although their hope of obtaining new vat dyes did not materialise—we know to-day that naphthacenequinones fail to give quinols in the same way as, *e.g.*, anthraquinones (Fieser, *J. Amer. Chem. Soc.*, **1931**, **53**, 2329). In this search for new dyes, Weizmann synthesised a series of more highly hydroxylated naphthacenequinones. Thus, condensation of hemipinic anhydride with 1 : 4-dihydroxynaphthalene afforded the keto-acid (IV) and eventually, after demethylation, a dye (V), an alizarin of the naphthacene series.

In respect to the mechanism of the boric acid synthesis, Weizmann supposed originally that a boric ester of α-naphthol is formed, which condenses more easily with phthalic anhydride than the free phenol; later, it became evident that boric acid stabilises the keto-acid (II) in form of a complex borate, *e.g.*, (VI), and thus prevents the isomerisation to (VII) which undoubtedly represents the intermediate in the formation of the undesirable naphthafluoran (I).

The condensation reactions of phthalic anhydrides that can be achieved by means of aluminium chloride or the combination of boric and sulphuric acids suffer from one disadvantage: the point of attachment of the *o*-carboxybenzoyl radical is not always unambiguous. In an attempt to find a synthetic method that would avoid this difficulty, Weizmann turned to the aromatic Grignard compounds. As early as 1905, he observed that α- and β-naphthylmagnesium bromide react with phthalic anhydride to give keto-acids (VIII and IX) which could be cyclised to 1 : 2-benzanthraquinone and naphthacenequinone, respectively. In later years, this method has been studied extensively; it has proved especially useful in the synthesis of carcinogenic hydrocarbons, in which the ability of the esters of such keto-acids to react with Grignard compounds RMgX preferentially at the keto-group led to compounds of type (X) (see, *e.g.*, Fieser and his co-workers, *J. Amer. Chem. Soc.*, 1937, **59**, 2331; 1938, **60**, 170).

The Aromatising Cracking of Hydrocarbons.—The occupation with polycyclic hydrocarbons led Weizmann to a study of the mechanism by which these compounds are formed at high temperatures from various hydrocarbon materials. This investigation resulted in a technical process for the production of the whole range of aromatic hydrocarbons (and of gaseous hydrocarbons, mostly of unsaturated nature) by cracking of petroleum or petroleum fractions at high temperature (680—700°) and at atmospheric pressure. The process is based on the fact that all non-aromatic hydrocarbons, independently of their structure and size, are degraded under these conditions to very small fragments, especially dienes and ethylenes, and that the latter combine by diene synthesis to hydroaromatic compounds which are eventually dehydrogenated. The investigation of this mechanism has uncovered a number of interesting new diene reactions, *e.g.*, with acenaphthylene, leading to fluoranthene derivatives :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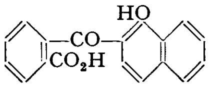
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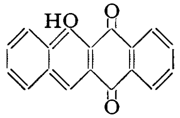
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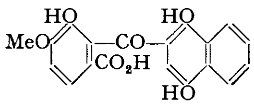
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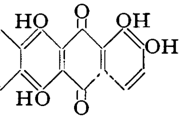
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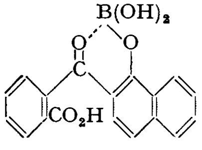
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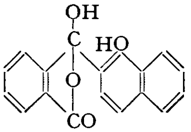
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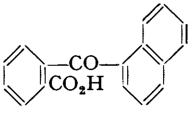
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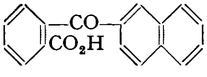
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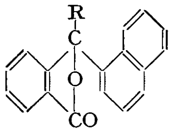
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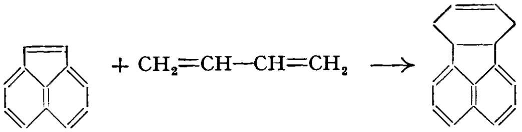


The Acetone–Butanol Fermentation and Related Subjects.—Weizmann's name in the scientific world has been closely connected with the discovery of the fermentation process producing acetone and butyl alcohol from sugar and starchy materials; the bacterium which causes this fermentation (*Clostridium acetobutylicum*) was distinguished from other micro-organisms which give the same or analogous products in that it contains a starch-splitting enzyme (in addition to a powerful protease). The history of this industrially valuable discovery, and its importance for the production of smokeless powder in the First World War and of butyl acetate for the manufacture of the lacquers that the rapidly growing automobile industry in the Twenties required, are too well known to warrant repetition. However, it may be interesting to record that Weizmann intended, when he began this investigation, to find a bacterium which would produce *iso*amyl alcohol and thus provide a suitable starting material for the production of isoprene and of synthetic rubber; in the early years of this century, the price of natural rubber rose so much that a synthetic polyisoprene appeared to be able to compete with the natural material.

The chemical potentialities of the two fermentation products have been exhaustively studied by Weizmann and his associates. A special study was devoted to the Guerbet reaction of butyl alcohol, which affords, on treatment of the compound with sodium or calcium at about 280°

(under pressure), 2-ethylhexanol and butyric (and some 2-ethylhexanoic) acid; it could be shown that this reaction can be formulated as follows:

$$CH_3{\cdot}CH_2{\cdot}CH_2{\cdot}CH_2{\cdot}OH \longrightarrow CH_3{\cdot}CH_2{\cdot}CH_2{\cdot}CHO$$

$$2CH_3{\cdot}CH_2{\cdot}CH_2{\cdot}CHO \longrightarrow CH_3{\cdot}CH_2{\cdot}CH_2{\cdot}CH{:}CEt{\cdot}CHO$$

$$CH_3{\cdot}CH_2{\cdot}CH_2{\cdot}CH{:}CEt{\cdot}CHO + CH_3{\cdot}CH_2{\cdot}CH_2{\cdot}CH_2{\cdot}OH \longrightarrow CH_3{\cdot}CH_2{\cdot}CH_2{\cdot}CH_2{\cdot}CHEt{\cdot}CH_2{\cdot}OH + CH_3{\cdot}CH_2{\cdot}CH_2{\cdot}CO_2H$$

The hydrogen required in the last step for the reduction of 2-ethylhex-2-enal can alternatively be supplied by 2-ethylhexanol already formed; thus, the formation of some 2-ethylhexanoic in addition to butyric acid finds its explanation. The correctness of this mechanism has been substantiated by a number of syntheses which suggested themselves on its basis, *e.g.*, the preparation of 2-alkyl*cyclo*hexanols from primary alcohols and *cyclo*hexanol.

Only in later years did Weizmann turn his attention to the biochemical mechanism of the acetone–butyl alcohol fermentation. It was found that the bacterium responsible for the fermentation requires three external growth factors: biotin, asparagine, and a third compound which was later identified as *p*-aminobenzoic acid. The last acid can be replaced by a number of analogues, amongst them *p*-aminophenylalanine. A study of the enzyme systems present in the micro-organism showed that it is able to reduce fatty acids to the corresponding alcohols. One is thus led to assume that it is distinguished from the analogous bacteria which are producing fatty acids, particularly butyric acid, by the presence of this powerful reducing mechanism.

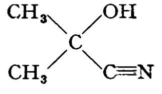
Weizmann was always conscious of the fact that this fermentation process leads to compounds containing three and four carbon atoms (in addition to some ethyl alcohol) and thus, potentially, to the substances on which the modern petrochemical processes are based. On many occasions, he stressed the technical and political implications of a change-over from a petroleum-based to a fermentation-based chemical industry, especially for countries poor in natural oil. When during the Second World War the shortage of natural rubber threatened the war effort of the Allies, and even the American petroleum industry seemed incapable of coping with the task of supplying the—identical—raw material for both synthetic rubber and aviation fuel, Weizmann suggested enlisting the help of the fermentation industry, and indeed a great part of the butadiene and the styrene used in the manufacture of synthetic rubber during the Second World War was derived from ethyl alcohol produced by fermentation processes.

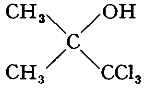
Various Subjects.—Amongst a number of investigations in the field of amino-acids, the study of the photochemical behaviour of the aqueous solutions of these acids may be mentioned. It was found that they are hydrolysed, on irradiation, to give ammonia and the corresponding α-hydroxy-acids. This reaction was suggested as a possible pathway for the formation of the α-hydroxy-acids in green plants, which are unusually rich in a variety of these compounds. In general, Weizmann paid much attention to photochemical reactions; thus, the light-induced interaction of ketones and alcohols was studied, and the results were interpreted by a mechanism according to which an activated ketone molecule abstracts a carbon-bound hydrogen atom from the alcohol group, yielding two radicals $RR'C(OH){\cdot}$ which can stabilise themselves by association or disproportionation.

As already reported briefly, during the Second World War Weizmann and his collaborators studied many processes of potential usefulness which are mostly described in patents. Thus, the well-known reactions of ketones and acetylene to give tertiary acetylenic alcohols and glycols, $HO{\cdot}CRR'{\cdot}C{\vdots}CH$ and $HO{\cdot}CRR'{\cdot}C{\vdots}C{\cdot}CRR'{\cdot}OH$, could be simplified considerably. By following up some indications in the literature, it was found that the condensation can be brought about by means of potassium hydroxide in certain solvents, *e.g.*, acetals or ketals; the preparation of metal derivatives of acetylene by the use of Grignard compounds or sodium in liquid ammonia is thus avoided. The acetylene derivatives so obtained open routes to several classes of compounds of theoretical and practical interest.

The same condensing agent—potassium hydroxide in acetals—can be employed usefully for many other reactions, *e.g.*, the condensation of chloroform with aldehydes and ketones, leading to trichlorinated alcohols, such as (XII) (from acetone). These alcohols not only resemble formally the α-hydroxy-nitriles (XI) from which unsaturated acids of the methacrylic acid type are made:

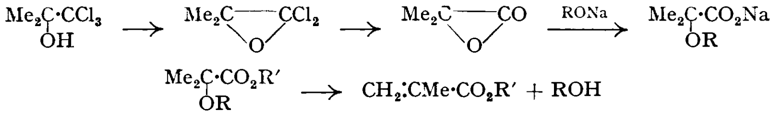
(XI)





(XII)

they, can indeed, be converted into these important unsaturated acids, although by a somewhat indirect route. When treated with a solution of alkali in an alcohol, (XII) is transformed into the alkali salt of an α-alkoxy*iso*butyric acid; the esters of the latter can be converted, catalytically or when heated with phosphoric oxide, into the corresponding esters of methacrylic acid. The following mechanism has been suggested for this sequence of reactions :



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